RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF

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Part 1.] 1905. [January.

REVIEW OF THE MINERAL PRODUCTION OF INDIA DURING THE YEARS 1898 TO 1903. BY T. H. HOLLAND, F.R.S., *Director, Geological Survey of India.* (With Plates 1—6.)

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I.—INTRODUCTION.

FOR the four years 1894 to 1897, a Review of the Mineral Production of India was issued annually by the Reporter on Economic Products; but in 1898 it was decided, owing to the want of uniformity in the rate of development of many minerals, to publish reviews of progress at wider intervals, covering periods sufficiently long to permit the determination of any decided secular variations in the mineral industry. The present Review, covering the period of six years, 1898 to 1903, is the first essay in this direction; but, in accordance with the orders of Government, five-year periods will be adopted for the future, and the Quinquennial Review of Mineral Production will be published in the Records of the Geological Survey of India.

Origin of the Review.

In this review the minerals are grouped according to the system laid down by Government ten years ago, namely—

Group I.—Those for which approximately trustworthy returns are available; and

Group II.—Those regarding which definitely recurring particulars cannot be procured.

In the first review, issued by Sir George Watt in 1894, the minerals referable to Group I included only Salt, Coal, Iron-ore, and Petroleum, and in the three subsequent issues of the same publication no advance was shown in transferring minerals from Group II to Group I. It is possible now, however, to raise several minerals to the level of those for which approximately trustworthy returns are available, and the minerals thus included in this group are:—

Grouping of the minerals.

Coal.	Mica.
Gold.	Petroleum.
Graphite.	Rubies.
Iron-ore.	Salt.
Jadeite.	Saltpetre.
Magnesite.	Tin.
Manganese-ore.	

In the case of Gold, the most precise and elaborate details are obtainable for more than 99 per cent. of the production, and approximate values are obtainable for the rest. For Graphite, accurate returns of quantity are obtained from the only company engaged in regular mining for the mineral. Although the returns sent in for the production of Jadeite and Mica are manifestly understated, both minerals are worked largely for export, and, as far as value is concerned, the export figures may be accepted as an approximate estimate of the trade in each case, whilst the nature of the error being known, the figures are not liable to be misleading. Manganese-ore has come into prominence since the older reviews were issued, and may now be transferred to Group I, as the mineral is worked entirely for export, and the totals obtained from returns made by the District Officers agree very closely with those obtained from the ports. Rubies admit of the remarks applicable to Gold: the amount recovered other than by the Burma Ruby Mines Company may be neglected as an unimportant fraction of the total. Saltpetre and Tin are, with less certainty, entitled to places in this group. For Saltpetre, the returns for production are evidently understated, being less each year than the quantity exported, but the export figures may be taken as only slightly less than those for the production of refined Saltpetre. The returns for Tin refer to two districts only in South Burma, but the estimates are probably more reliable than those for Iron, which was originally included in Group I.

Missing minerals.

This Review is directed primarily to a survey of the progress already made, and for anything approaching an idea of the material awaiting development the reader must consult the Manual of Economic Geology, now in course of revision by the Geological Survey Department. But besides the substances whose existence has been determined by the exploratory work to which a geological survey is properly restricted with regard to minerals of economic value, the attention of prospectors might be directed to the minerals which have lately come into prominence through recent industrial developments, and which, in a country including the geological variety of India, are at present conspicuous by an absence that is probably only the result of absence of search. Amongst these are some minerals of the so-called rare metals, which, being generally of high specific gravity, should be searched for in the heavy concentrates of river gravels (see p. 114).

Units recognized.

Unless otherwise specified, the ton is invariably taken in this Review to be the English statute ton, or the so-called long ton of 2,240 lbs. To facilitate comparison with the returns of foreign countries, many of the larger quantities are also calculated to metric tons of 1,000 kilogrammes each. As exchange has been steadily maintained at the rate of Rs.15=£1 throughout the period under review, all values are expressed in terms of the sterling unit.

Sources of information.

The data employed in this Review have been mainly extracted from the publications issued by the Director-General of Statistics; but additional information has been obtained from the following sources:—

(1) Annual Reports of the Gold Mining Companies on the Kolar field, kindly supplied by the Managing Agents.

(2) Annual Reports of the Chief Inspector of Mines for India and the Chief Inspector for Mysore.

(3) Administration Reports of the various Local Governments and Local Administrations in India.

(4) Administration Reports of the Railways.

(5) Reports issued by various foreign Geological Surveys, and Statistics relating to Mines and Quarries, published by the English Home Office.

The writer is also indebted to the Managing Agents of several mining companies for much information supplied direct, and he is especially indebted to Mr. J. A. Robertson, Director-General of Statistics, for assistance in analysing the data hitherto published only in consolidated tables.

II.—SUMMARY OF PROGRESS.

Total values.

THE following table summarizes the values of the principal minerals produced during the six years under review. The totals have the obvious defect of being due to the addition of unlike denominations; for export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values*, but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan or Burma; in the case of salt, the values given are the prices charged, and these, on an average, are but one-tenth of the duty, which is the principal value of the salt to Government; certain valuable mineral products, like building-stone, are omitted altogether for want of even approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if the minerals were consumed in the country, and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product which, according to its quality, may be worth 30 to 40 shillings a ton to the European steel-maker, but which is of less value to the Indian producer by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

The imperfections of the table are those confessedly inseparable from all such estimates of mineral production; and it is of use merely as a means of comparing one year with another, the same system being carried through the whole period under review. It will be seen that there has been, year by year, a steady, uninterrupted progress in production, from a total of £3,455,565 in 1898, to £4,988,527 in 1903—an increase of 44·37 per cent. in five years. To this total increase every mineral has contributed, except jadeite and amber, and for both of these the figures are of more doubtful value than for most of the other minerals.

TABLE I.—*Total Value of Minerals for which Returns of Production are available for the years 1898 to 1903.*

MINERALS.	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
	£	£	£	£	£	£	£
Gold . . .	1,608,504	1,724,906	1,891,767	1,930.411	1,970,23[illegible]	2,302,493	*1,904,710*
Coal (*a*) . . .	957,162	1,063,820	1,343,081	1,323,372	1,366,909	1,299,716	*1,225,677*
Salt (*b*) . .	358,933	312,682	325,970	409,019	344,633	336,147	*347,807*
Saltpetre (*c*) . .	265,896	232,896	256,210	294,249	237,880	288,487	*252,603*
Petroleum (*a*) .	67,897	125,684	148,755	200,342	217,816	354,365	*185,810*
Rubies . .	57,950	90,848	97,326	104,476	86,895	98,575	*89,345*
Mica (*c*) . . .	53,890	73,372	109,554	70,034	87,594	86,277	*80,1[illegible]0*
Manganese-ore .	27,426	39,529	77,304	79,119	120,538	132,741	*79,443*
Jadestone (*c*) . .	41,780	42,120	58,955	46,377	31,713	47,676	*44,770*
Iron-ore (*e*) . .	12,403	12,836	11,171	13,598	16,533	14,563	*13,584*
Graphite (*d*) . .	110	7,620	9,145	13,635	24,410	16,970	*11,981*
Tin . . .	2,553	7,900	8,534	7,773	5,340	9,153	*6,875*
Magnesite (*d*) . .	...	56	150	...	2,360	550	*519*
Amber . . .	1,061	151	103	11	432	414	*362*
TOTAL .	**3,455,565**	**3,734,420**	**4,338,025**	**4,492,416**	**4,513,283**	**4,988,527**	*4,253,705*

(*a*) Spot prices
(*b*) Prices without duty.
(*c*) Export values.
(*d*) Estimated values.
(*e*) Estimated values for provinces other than Bengal.

General character of the minerals worked.

On looking over the returns for mineral production in India for the past six years, two features stand out most conspicuously. Firstly, there has been a remarkable progress in developing the few minerals which are consumed by what conveniently might be called direct processes, such as Coal, Gold, Petroleum, Gem-stones, and Salt, or which are raised for simple export, such as Manganese-ore, Graphite, Saltpetre, Mica, and Tin. Secondly, there has been an equally remarkable neglect of the metalliferous ores and the minerals which are necessary to the more complicated chemical and metallurgical industries.

The neglect of metalliferous ores.

The principal reason for the neglect of metalliferous minerals is the fact that in modern metallurgical and chemical developments the bye-product has come to be a serious and indispensable item in the sources of profit, and the failure to utilize the bye-products necessarily involves neglect of the minerals which will not pay to work for the metal alone. Copper sulphide ores are conspicuous examples of the kind: many of the most profitable copper mines in the World could not be worked but for the demand for sulphur in sulphuric acid manufacture, and for sulphuric acid there would be no demand but for a string of other chemical industries in which it is used (*cf.* page 117). A country like India must be content, therefore, to pay the tax of imports until industries arise demanding a sufficient number of chemical products to complete an economic cycle, for chemical and metallurgical industries are essentially gregarious in their habits.

Value of mineral imports.

An examination of our import statistics shows how far the domestic production falls short of the requirements of the country in minerals and mineral products. During the three years 1901-1903 the average annual value of these imports was £10,158,252, and this figure does not include the value of glassware, earthenware, porcelain, machinery, railway material, hardware, and the innumerable articles which, though made from metals known to exist in India, have values greatly in excess of the raw materials used in their manufacture, and which, in any case, would be partly made elsewhere. Of the average annual total, 54·7 per cent., or £5,559,511, was paid for metals alone.

Summary for the Minerals of Group I.

Coal.

In the case of Coal, the Indian output has risen from a little over 4 million tons in 1897 to 7½ million tons in 1903, and within the period under review, India, for the first, though probably also for the only, time, secured the leading place as a coal-producer amongst British dependencies. Of the total output, the Bengal coal-mines contributed the chief, and an annually increasing, fraction, from 78·6 per cent. in 1898 to 85·5 per cent. of the total in 1903. On account of the fact that very little development has occurred in metallurgical industries, the coal consumption of India is not likely greatly to exceed that of Australia, and will certainly fall behind that of Canada, until our metalliferous ores, and especially those of iron, are raised for smelting in the country.

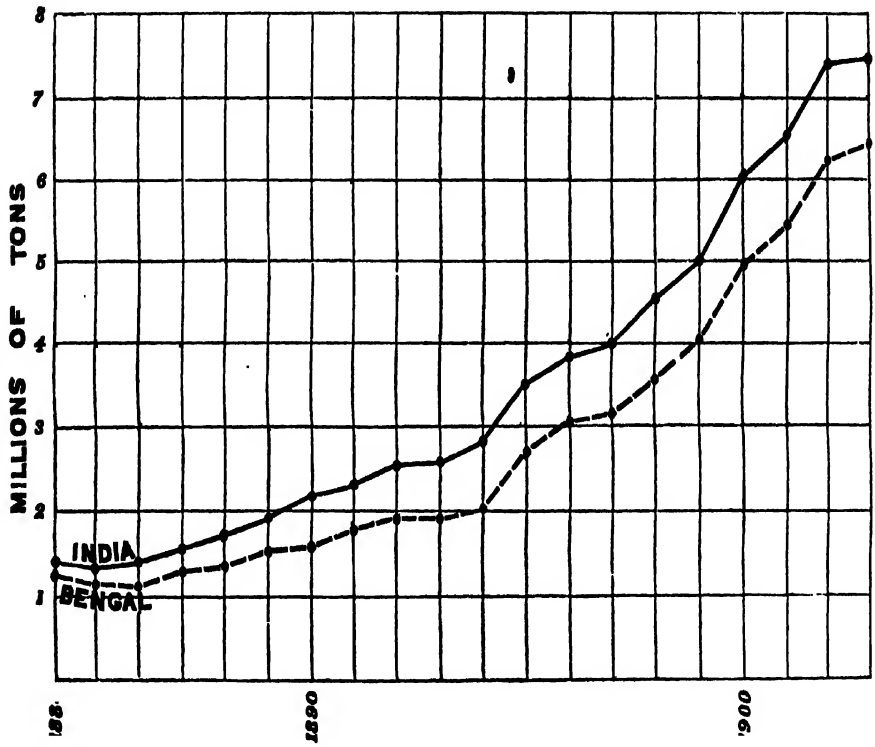


FIG. 1.—*Production of Coal for 20 years.*

As far as they go in their small way, it is satisfactory, from the coal-miners' point of view, to observe that, within the period under review, the figures for imports and exports have become reversed, with every sign of permanency in their present relative positions (figure 2, page 10).

Another feature of the coal trade—which is satisfactory also to those with wider interests than the coal-miner—is the fact that whilst the railways have reduced their purchases of foreign coal to the dimensions of mere samples—as shown graphically in figure 3 (page 11)—and whilst their total coal bill has been steadily increasing, they have been, at the same time, taking year by year a gradually shrinking fraction of the total output of the mines—a fact which indicates that other coal-consuming, industrial enterprises have developed at a greater rate than railway expansion.

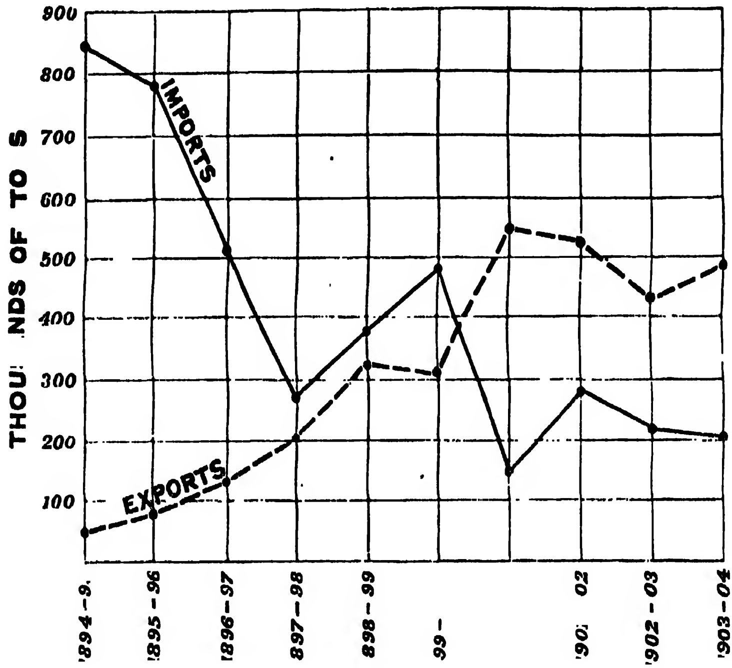


FIG. 2.—*Exports and Imports of Coal for the past 10 years.*

Gold. The production of Gold has shown a steady increase, from a total of 390,595 ounces, valued at £1,568,065, in 1897, to 603,218 ounces, valued at £2,302,492, in 1903. The progress since 1890 is shown in figure 4 (page 12).

By far the largest fraction of the output has been obtained from a single reef in the Kolar field, Mysore State, but promising work in reef-mining has recently been commenced in the Nizam's Dominions and in the Dharwar district, Bombay Presidency, whilst preparations are being made for an extension of dredging operations on the gravels of the Upper Irawadi river in Burma.

Graphite. Amongst the minerals which have been taken up more seriously during the period under review, the Graphite of Travancore and the Magnesite of Salem in Madras are noticeable. The Graphite raised during the three years

1901 to 1903 averaged 3,486 tons per annum, which is quite a serious item in the comparatively small market of this mineral. The total annual production of graphite in the World varies between 70,000 and 80,000 tons, and the Indian output is thus about 4½ per cent. of the total quantity raised, but its value is not returned, and is estimated in the summary table at £5 a ton.

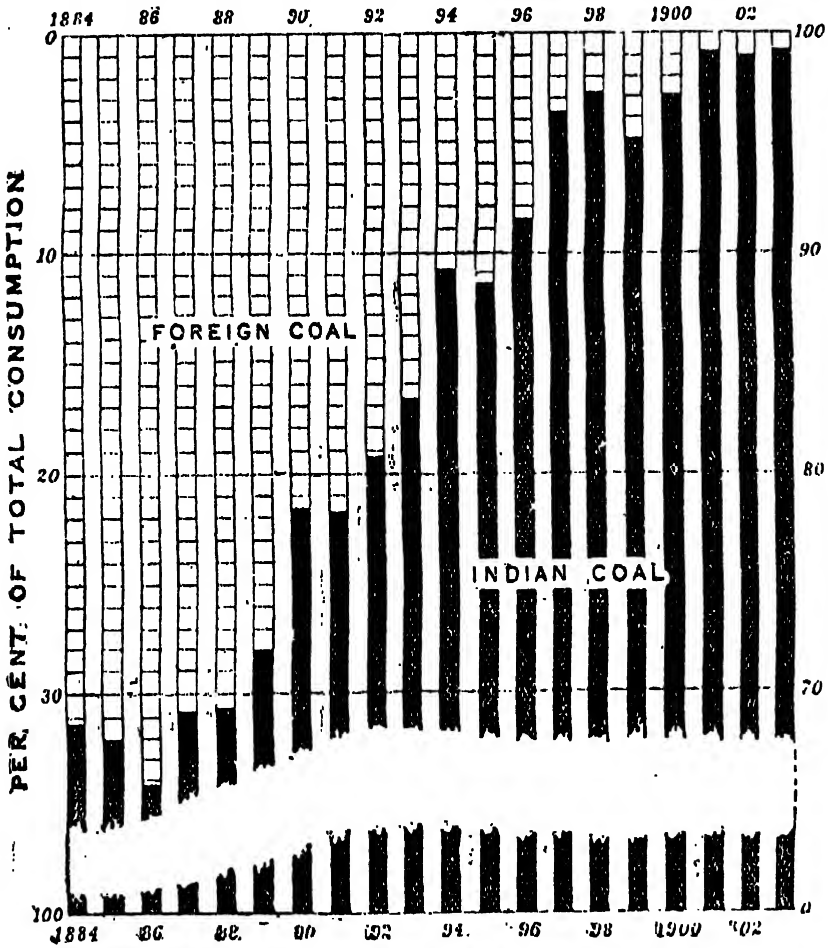


FIG. 3.—*The relative Consumption of Foreign and Indian Coals on Indian Railways during the 20 years 1884 to 1903.*

Iron.

The works at Barakar still remain as the one successful attempt to manufacture Iron along European lines in India. Prospecting operations on an extensive scale have been carried on recently in the Central Provinces, the results in one area being unfavourable and in the other undetermined. There is a general decline in the native charcoal-iron industry within range of the railways which distribute the cheap imported material, but in more remote parts of the Peninsula the old industry persists, and in parts of the Central Provinces has even improved. In the Sambalpur district there are over 200 small direct-process furnaces still at work.

During the six years under review the average annual value of iron and steel imported was £3,078,065, but as this does not include the amounts brought in in the form of machinery, the figures would present a very different appearance if workshops and foundries were more widely developed in India. As the imports of iron and steel have been rising year by year, and were valued at £4,136,184 in 1903, the figures, as far as they go, are quite sufficient to show that there is room in the country for a large iron-manufacturing industry, which would soon bring in its train the manufacture of machinery.

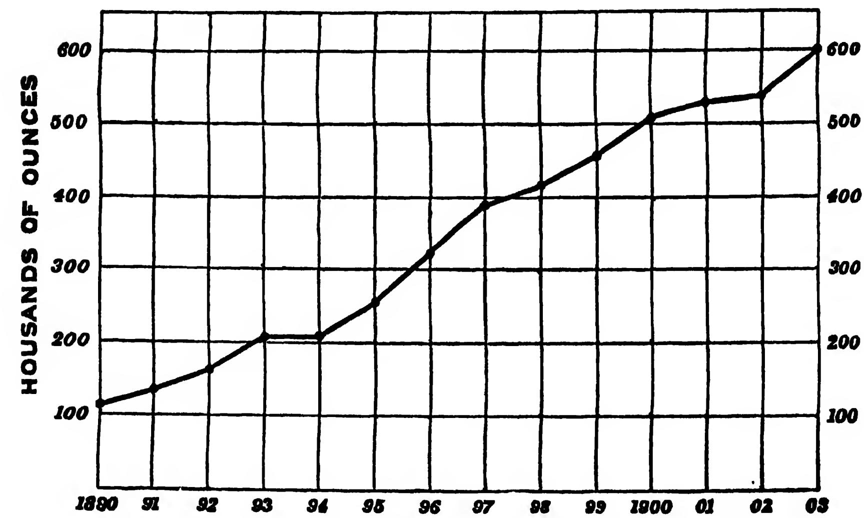


FIG. 4.—*Production of Gold since 1890.*

Jadeite.

From the fact that the district returns for production show little more than half the quantities of "Jadestone" declared in the export statistics, it is evident that less interest is taken in the mineral than its value appears to justify. With an average annual value of £44,770 returned for the exports to the Straits and China, jadeite should be ranked amongst the important minerals, its value being nearly seven times that of the tin turned out and nearly half that of rubies.

Magnesite.

Magnesite-mining was hardly established before the close of 1903, but preparations on a large scale are now being made to open up the well-known deposits near Salem, in which the mineral occurs in a condition of exceptional purity.

Manganese-ore.

The rapid rise of Manganese-ore mining is probably just now the most conspicuous feature in the mineral industry of India. Twelve years ago the industry had not definitely started, whilst last year India turned out a larger quantity of high-grade ores than any country except Russia. The diagram forming figure 5 shows that, within the period under review, work commenced in the Central Provinces, and on account of the high degree of richness and purity of the ore-bodies there opened up, production rapidly developed, in spite of the handicap of a railway journey of 500 to 600 miles between the mines and the coast. The recent discovery of deposits in the Bombay Presidency nearer the coast will probably result in a still further expansion of the export trade, which, however, in view of the unlimited fuel supplies lying idle in India, and the annually increasing bill for imported steel, cannot be regarded with unmixed satisfaction.

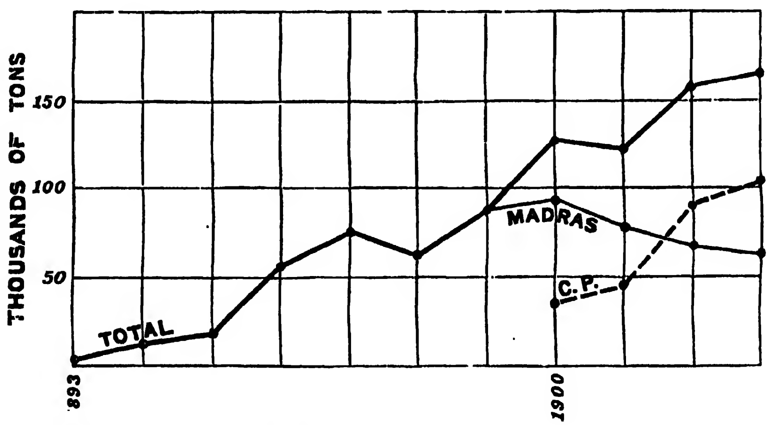


FIG. 5.—*Production of Manganese-ore since the commencement in 1893.*

Mica.

Although India is still the leading producer, and is supplying something like half the World's wants in Mica, the miner in India has not secured a satisfactorily large share of the recently increased trade in this mineral, and the returns for India show a smaller degree of expansion than those for consumption in Europe and America.

Figure 6, showing the fluctuations in total weight and total value of the mica exported, demonstrates in an interesting way the change which took place in the ratio of the two, when, near the beginning of the period under review, the Indian mica-miners began to turn over their waste heaps to supply the demand for the cheaper "flimsy" mica required for the newly-invented micanite.

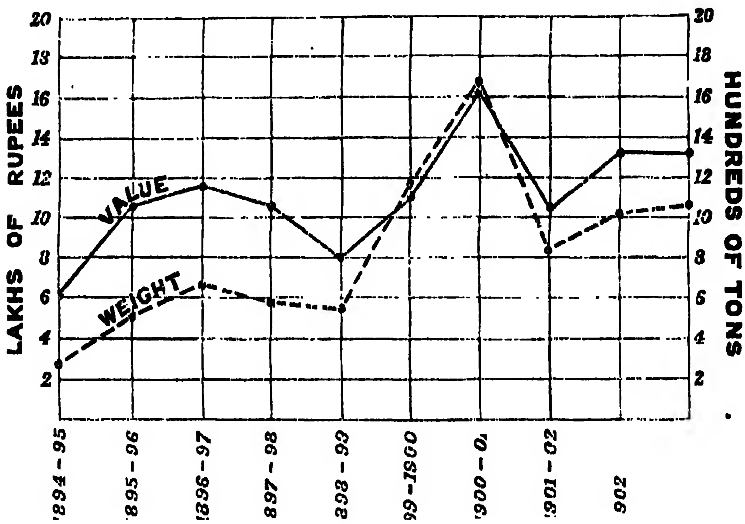


FIG. 6.—*Exports of Indian Mica during the past 10 years.*

Petroleum.

The Petroleum industry has increased at a greater rate even than coal-mining. From a production of just 19 million gallons in 1897, the output rose to nearly 88 million gallons in 1903, and in addition to the export of considerable quantities of paraffin wax, the illuminating oils and petrol refined in Burma and Assam have at last shown signs of definitely displacing foreign supplies in the Indian market (figure 7, page 15).

Rubies.

Next to Petroleum, Rubies now form the chief source of revenue amongst mineral products in Burma, the Ruby-Mining Company under the new lease having entered a favourable phase after a long period of uncertainty in its prospects. The Company paid its first dividend of 5 per cent. in 1898, and continued to work with greater profits in 1899 and the following years.

Salt.

The production of Salt has shown considerable fluctuations, from 1,102,039 tons in 1901 to 823,184 tons in 1903, the average annual production for India, exclusive of Aden, having been 979,572 tons for the period under review. Of this amount 61·8 per cent. was obtained from sea-water, 27 per cent. was obtained from sub-soil brine and from lakes in areas of internal drainage, whilst the remainder, 11·2 per cent., was raised from the rock-salt deposits in the Punjab and North-West Frontier Province. The average annual import of foreign salt amounted to 433,754 tons, of which 89·8 per cent. was imported to Bengal, and 10·1 per cent. entered Burma.

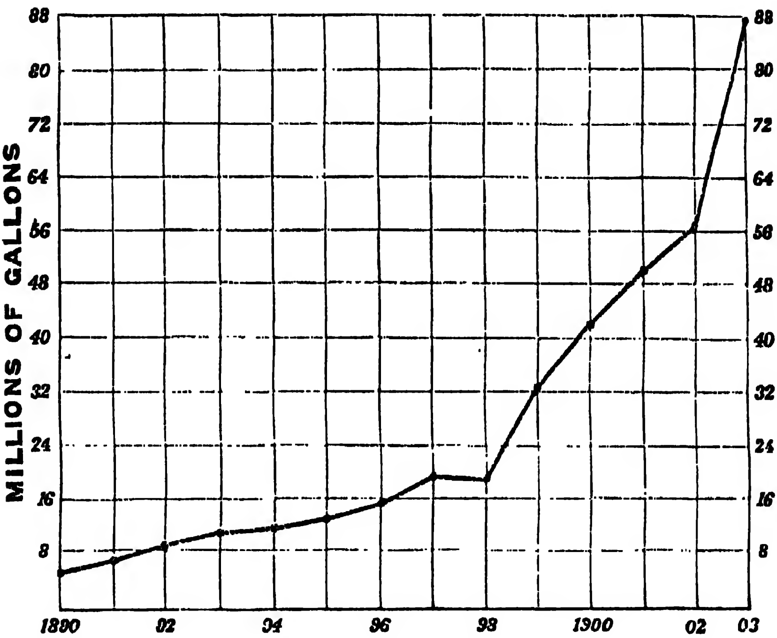


FIG. 7.—*Production of Petroleum since 1890.*

The production of Saltpetre is evidently understated, being considerably below the quantities returned as exports. The average annual exports for the six years amounted to 382,353 cwt., of which 30·7 per cent. went to the United Kingdom, 25·7 per cent. to Hong-Kong, and 24·0 per cent. was exported to the United States. Most of the saltpetre was manufactured in Behar, and 98·5 per cent. of the total left India through the port of Calcutta. The only trans-frontier trade of importance is the import of saltpetre from Nepal, the average annual amount for the period under review being 9,417 cwts.

Saltpetre.

Tin.

Although Tin-mining in South Burma is still practised on a small scale, there has been a marked improvement in the returns, and the persistently high price of tin is likely to inspire more enterprise in the exploitation of these deposits, which are a natural continuation of those in the Malay Peninsula, from which more than half the World's supply is obtained.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Coal.

DURING the period of six years under review, the output of Coal rose from a total of 4,066,294 tons in 1897 to 7,438,386 tons in 1903, an increase of 83 per cent. (table 2). The expansion was, however, mostly confined to the first five years of this period, as in 1903 the production exceeded that of 1902 by only 13,906 tons.

Progress in output.

TABLE 2.—*Production of Coal during the years 1898 to 1903.*

YEAR.	Quantity.	Total value at the place of production.	*Average value per ton at the mines.*
	Tons.	Rupees.	*Rupees.*
1898	4,608,196	1,43,57,436	3·12
1899	5,093,260	1,59,57,301	3·13
1900	6,118,692	2,01,46,222	3·29
1901	6,635,727	1,98,50,582	2·99
1902	7,424,480	2,05,03,639	2·76
1903	7,438,386	1,94,95,741	2·62

From this table it will be noticed that during the latter half of the period under review supplies began to exceed the demand, and lower prices, on an average, were accepted. The average *prices* paid for coal at the pit's mouth are rather unfairly stated as *values*, but the figures are nevertheless interesting as indications of the rates at which coal can be raised with profit. The average rate given as Rs. 2·76 (3*s*. 8*d*.) in 1902 was much

Prices.

below that of most coal-producing countries of the same year. The following table shows the declared pit-mouth value in some other countries for 1902 :—

Countries.	Per ton.	Countries.	Per ton.
	s. d.		s. d.
United Kingdom . .	8 2¾	Australia . . .	7 9
Germany	8 10½	New Zealand . . .	10 0
United States . . .	5 8½	Canada	9 3

Comparison of India with Canada and Australia.

A reference to table 3 will show that in 1902 India, for the first time, secured the leading place as a coal-producer amongst the British dependencies, although the amount of coal raised was only 2·95 per cent. of the total for the British Empire in the same year, and only 0·94 per cent. of the World's total output. The figures are not mere curiosities to those who know the leading conditions affecting production. In 1895 Canada produced more coal than India, but India then began to supply the eastern steamship companies in consequence of the high prices produced by the English colliers' strikes of the two preceding years, and for the first time the returns for 1896 showed that India was leading as coal-producer, but was still well behind Australia. Australia was overtaken in 1902, and India thus enjoyed the first place; but it is unlikely that this position will be occupied for more than the one year, and the returns for 1903, when published, will probably show India giving way, not to Australia, but to Canada. If this prove to be true, the causes will be worth the attention of those interested in Indian coal-mining. Canada for many years was a small producer of iron and steel, and its rich deposits of iron-ore in the region of the Great Lakes, where Canadian territory is without coal deposits, were worked for export to the adjoining States of the American Union. In 1900 the total production of pig-iron in Canada amounted to 86,090 tons and of steel 23,577 tons only; but iron and steel works were started in the chief coal-producing colony, Nova Scotia, at the end of 1901, and the result is a reported production of 319,557 tons of pig-iron and 182,037 tons of steel for 1902. Iron and steel-making, more than most manufacturing industries, creates a market for coal, and if this industry flourishes in Canada, India will resume its second place as a coal-producer until its resources in iron-ore can, in the same way, be utilized for the consumption of coal. Australia at present is, like India, dependent for most of its iron supplies from outside sources, and, like India, must depend on other industries and on exports for a coal market.

TABLE 3.—*Production of Coal in the three large British Dependencies.*

COUNTRIES.	1898.		1899.		1900.		1901.		1902.	
	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*
Australia .	5,490,776	2·49	5,539,382	2·31	6,479,991	2·61	7,000,227	2·86	6,968,514	2·72
Canada .	3,785,372	1·72	4,142,202	1·73	4,837,291	1·95	5,612,108	2·29	6,930,220	2·71
India .	4,203,199	1·91	5,016,390	2·09	6,216,882	2·51	6,742,214	2·76	7,543,625	2·95
TOTAL for British Empire.	220,301,426		239,895,148		247,938,725		244,463,996		256,003,411	

Relation of consumption to production.

The market for Indian coal must be limited to (1) its own home industries, and (2) the Indian Ocean ports, where the manufacturing industries requiring coal are comparatively few, and where India is not the sole supplier of fuel. Tables 4 and 6 show that during the last six years India consumed on an average 93·1 per cent. of the coal produced in the country, and, in addition, imported annually on an average 298,940 tons of foreign coal, which must have been, in calorific value, very little below the slightly larger quantity of Indian coal sent out of the country during the same period.

The actual annual increment of consumption since 1897 has been, on an average, 509,919 tons a year, whilst the increment of production during the same period has averaged 562,015 tons. As the figures for consumption and production do not differ seriously, the great expansion which has taken place in the Indian coal trade must have been made possible by industrial developments in India itself. The next few years will show whether this expansion is a correct index to the development of other industries, or whether it is the result mainly of increased facilities of transport and of consequent access to new markets.

TABLE 4.—*Relation of Consumption to Production.*

YEAR.	Total consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.(a)	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1898 . . .	4,660,154	4,280,929	92·9
1899 . . .	5,269,563	4,788,373	94·1
1900 . . .	5,719,136	5,576,669	91·1
1901 . . .	6,396,466	6,110,680	92·1
1902 . . .	7,221,241	6,992,679	94·2
1903 . . .	7,189,167	6,996,438	94·1
Average .	*6,075,954*	*5,790,961*	*93·1*

(a) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the exports a ton of coke is taken to be equivalent to 1½ tons coal required for its production. The imports include Government stores.

Consumption of coal on Indian railways.

The railways in India have consumed on an average 29·7 per cent. of the coal produced during the past six years and table 5 shows that there has been a slight tendency for the consumption of Indian coal on the railways to form a gradually smaller fraction of the output from the mines. This is probably not merely a temporary effect, as the figures for a corresponding period ten years back, namely, 1888 to 1893, show, when treated in the same way, that the consumption of Indian coal on the railways averaged at that time 32·6 of the production. As the differences between exports and imports have been, on an average, insufficient to affect seriously the figures for total coal consumption, and as the railways in India now consume a smaller percentage of the output than in former years, the expansion in Indian coal production may be regarded as a partial measure of the expansion of other industrial enterprises. It is not a complete measure of such expansion, as new markets have been found in recent years for Indian coal; and as probably most of the available markets have been entered now, the rate of increase in production in the future will be more nearly limited to the rate of expansion in the industries of the country. For this reason, the future of Indian coal-mining would be brighter if there were a prospect here, as in Canada, of a sensible development of the metallurgical industries; these are the real consumers of coal, and it is only when they are developed in India that the expansion in coal-mining will make a serious inroad into the enormous supplies of coal available in the country.

TABLE 5.—*Coal consumed on Indian Railways during the years 1898 to 1903.*

YEAR.	INDIAN COAL.			FOREIGN COAL.		TOTAL Consumption.
	Quantity.	*Per cent. of Total.*	Per cent. of Indian output.	Quantity.	*Per cent. of Total.*	
	Tons.			Tons.		Tons.
1898 . . .	1,422,103	97·3	30·9	39,004	2·7	1,461,107
1899 . . .	1,557,000	95·0	30·6	82,446	5·0	1,639,446
1900 . . .	1,855,610	97·2	30·3	54,339	2·8	1,909,949
1901 . . .	1,956,601	99·3	29·5	13,248	0·7	1,969,849
1902 . . .	2,091,992	99·0	28·2	21,469	1·0	2,113,461
1903 . . .	2 203,889	99·2	29·6	17,696	0·8	2,221,585
Average .	*1,847,866*	...	*29·7*	...	...	...

Foreign coal on Indian railways.

The country is now rapidly assuming the position of supplying its whole wants in mineral fuel. Table 6 and figure 2 (page 10) show that the imports of foreign coal for all purposes have been gradually diminishing, whilst table 5 and figure 3 show that on the railways foreign coal has been almost entirely cut out. Twenty years ago the foreign coal consumed on the railways amounted to 31 per cent. of the total; ten years ago this was reduced to 10·7 per cent., whilst during the past six years the foreign coal has averaged 2·16 per cent. of the supplies to the railways, and during the last three years this has been reduced to under 1 per cent. In other words, twenty years ago foreign coal was a serious item in the fuel supplies of the railways: it is now imported in mere samples.

Imports and exports.

The interchange of positions, which has occurred between exports and imports during the last 20 years, is clearly shown in figure 2, and in more detail on plate 1. The actual reversal has occurred within the period under review, as shown in table 6.

TABLE 6.—*Imports and Exports of Coal during the years 1897-98 to 1902-03, including Government Stores.*(*a*)

YEAR.	Imports.	Exports.
	Tons.	Tons.
1897-98	276,407	213,146
1898-99	379,225	327,267
1899-00	481,190	304,887
1900-01	142,467	542,023
1901-02	285,786	525,047
1902-03	228,562	431,801
Average .	298,940	390,695

(*a*) The figures include coke and patent fuel, each ton of coke being counted as 1½ tons of coal.

It is important to observe, with regard to both imports and exports, that the reversal of position, although it looks striking when expressed in diagrammatic form, has taken place on comparatively small quantities, both being insignificant beside the production and consumption within India itself.

The countries from which foreign coal supplies have been obtained are shown in table 7, from which it will be seen that the principal portion of the supplies has been obtained from Great Britain, and that practically all of the remainder has come from Australia and Japan.

Imports.

TABLE 7.—*Origin of Imported Coal, Coke, and Patent Fuel.*

YEAR.	United Kingdom.	Australia.	Japan.	Other Countries.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.
1897-98 . .	245,555	16,406	14,213	233	276,407
1898-99 . .	326,794	18,778	32,281	1,372	379,225
1899-00 . .	375,269	20,282	82,936	2,703	481,190
1900-01 . .	98,315	14,638	27,967	1,547	142,467
1901-02 . .	211,327	19,685	53,440	1,334	285,786
1902-03 . .	210,904	6,237	6,975	4,446	228,562
Average .	*244,694*	*16,005*	*36,302*	*1,939*	*298,940*

The distribution of exported Indian coal is shown in table 8, from which it will be seen that Ceylon and the Straits Settlements have taken the principal share, the averages for the six years being 246,352 tons of coal in the case of Ceylon and 85,095 tons in the case of the Straits, the returns for coke being of small importance.

Exports.

The variations in exports to the two chief customers are shown graphically on plate 1. Of the causes which led to the decline in the exports to Ceylon during the last three years, one has been reported to be the unfavourable reputation earned by the shipment of inferior coal to meet the increased demands made in 1900. If this is the case, the cure is in the hands of the Bengal coal-owners, for the demand must have been no real strain on the supplies available, and the figures given in table 9 will show that the markets of Ceylon and Singapore are

Possible expansion of the export trade.

both large enough to be worth the serious attention of Indian coal-shippers.

TABLE 8.—*Exports of Indian Coal.*

—	1897-98.	1898-99.	1899-00.	1900-01.	1901-02.	1902-03.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden . . .	8,094	14,416	4,000	53,305	47,194	21,214	*24,704*
British East Africa .	3,619	150	...	20,569	16,922	11,562	*8,804*
Ceylon . . .	104,524	214,986	180,909	368,031	335,651	274,010	*246,352*
Mauritius . .	7,317	2,708	18,128	5,759	18,745	14,690	*11,224*
Natal . . .	...	287	6,072	598	160	2,324	*1,573*
Straits Settlements .	85,280	93,462	86,951	65,715	89,592	89,567	*85,095*
Sumatra . .	...	...	3,531	10,863	10,690	14,655	*6,623*
Other Places . .	3,439	769	4,392	15,450	5,012	3,032	*5,349*
TOTAL Exports .	212,273	326,778	303,983	540,290	523,966	431,054	389,724
	£	£	£	£	£	£	£
VALUE .	142,283	223,100	217,776	393,889	375,977	257,968	268,499

TABLE 9.—*Foreign Coal Imports of Ceylon and Singapore for the years 1901 to 1903.*(a)

ORIGIN OF THE COAL.	CEYLON.			SINGAPORE.		
	1901.	1902.	1903.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
England .	286,842	288,362	246,500	60,419	50,984	52,500
Japan . .	6,300	...	26,400	433,548	370,426	400,000
Australia . .	5,522	3,752	12,200	38,965	36,087	44,500

(a) For Indian coal sent to Ceylon and Singapore, see table 8.

Practically all the coal exported leaves by the port of Calcutta, which, being the nearest port to the Bengal coal-fields, is the centre of distribution to the other ports of India. The quantity exported from Calcutta during the past six years is shown in table 10 to have averaged 1,622,686 tons, with the two highest records in 1901 and 1903 and a distinct general increase from the year 1898 onwards.

Calcutta exports.

TABLE 10.—*Coal shipped from Calcutta during the years 1898 to 1903.*

—	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
To Foreign Ports .	314,562	269,112	488,555	587,100	428,995	438,975	*421,216*
„ Indian Ports .	906,509	867,161	1,245,996	1,407,913	1,267,528	1,513,711	*1,201,470*
TOTAL .	1,221,071	1,136,273	1,734,551	1,995,013	1,696,523	1,952,686	*1,622,686*

Of Indian ports, Bombay is by far the most important market for Bengal coal, having, during the period under report, taken on an average 679,445 tons a year, with a maximum of 881,806 tons in the last year, 1903. The amount of Bengal coal taken at Bombay is now well beyond the foreign imports, which, during the same period, averaged 192,237 tons, by far the largest fraction having come from the United Kingdom.

The distribution of Bengal coal to Indian ports is shown in table 11, on page 26, from which it will be seen that the places of importance after Bombay have been, in order, Rangoon, Madras, Karachi, Cuddalore, and Negapatam.

Table 12 (page 27) shows that amongst the provinces Bengal occupies the leading position as a coal-producer, whilst a glance at figure 1 (page 9) will show that the Bengal output is not only the largest part, but has been a yearly increasing fraction of the total, the contribution having risen from 78·6 per cent. in 1898 to 85·5 per cent. in 1903. Three coal-fields in Bengal, namely, Raniganj, Jherria, and Giridih, have yielded nearly all the coal hitherto credited to Bengal, but the Daltonganj field, which is now connected with the East Indian Railway system, has recently been opened up by the Bengal Coal Company.

Production by provinces.

TABLE 11.—*Distribution of Bengal Coal to Indian Ports.*

PLACES.	1898.	1899.	1900	1901.	1902.	1903.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Akyab . .	1,614	2,167	5,575	6,160	9,745	2,293	*4,592*
Balasore . .	2,681	219	4	...	...	13	*486*
Bassein . .	...	4,622	3,900	7,221	15,112	9,852	(*b*) *8,141*
Bhownagar .	...	...	...	...	...	15,690	(*a*) *15,690*
Bombay . .	449,302	399,121	824,080	861,859	660,504	881,806	*679,445*
Chandbali . .	6,985	1,875	625	465	192	212	*1,726*
Chittagong .	785	2,671	3,791	3,637	2,288	3,374	*2,758*
Cocanada . .	100	...	...	4,226	...	1,000	*888*
Cuddalore . .	22,635	28,706	12,088	31,591	21,492	33,293	*24,968*
Karachi . .	20,801	...	4,730	14,108	84,825	54,824	*29,881*
Kyaukpyu . .	473	514	605	497	181	40	*385*
Madras . .	193,102	193,667	136,189	173,171	150,850	170,760	*169,623*
Mandapam . .	...	...	...	...	...	13,974	(*a*) *13,974*
Marmagoa . .	...	...	...	...	...	14,380	(*a*) *14,380*
Moulmein . .	1,359	1,120	2,270	1,338	3,571	1,619	*1,879*
Negapatam .	24,226	18,930	28,199	31,009	23,754	21,557	*24,613*
Pondicherry .	...	6,120	3,994	10,088	7,571	5,000	(*b*) *6,555*
Port Blair . .	750	1,000	1,000	750	6,000	6,009	*2,585*
Rangoon . .	169,979	188,619	209,469	242,777	261,213	264,344	*222,734*
Tuticorin . .	10,677	17,007	9,237	18,285	12,505	12,918	*13,438*
Other Ports .	1,040	803	240	731	7,725	753	*1,882*
TOTAL .	906,509	867,161	1,245,996	1,407,913	1,267,528	1,513,711	*1,201,470*

(*a*) One year only. | (*b*) Average for 1899 to 1903 only.

TABLE *Output of Indian Coa by Provinces for the years 1898 903.*

YEAR.	Assam.	Baluchistan.	Bengal.	Burma.	Central India.	Central Provinces.	Hyderabad.	Punjab and Kashmir.	Rajputana.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898	200,329	13,372	3,622,090	6,975	134,726	149,709	394,622	85,862	511	4,608,196
1899	225,623	15,822	4,035,265	8,105	164.569	156,576	401,216	81,835	4,249	5,093,260
1900	216,736	23,281	4,978,492	10,228	164,489	172,842	469,291	74,083	9,250	6,118,692
1901	254,100	24,656	5,487,585	12,466	164,362	191,516	421,218	67,730	12,094	6,635,727
1902	221,096	33,889	6,259,236	13,302	171,538	196,981	455,424	56,511	16,503	7,424,480
1903	239,328	46,909	6,361,212	9,306	193,277	159,154	362,733	44,703	21,764	7,438,386

Geological origin of the coal.

Most of the coal raised has been obtained from the Gondwana system of strata in Peninsular India, where the coal-mines, being nearer the coast, and generally within touch of the main railway lines, have been developed more rapidly than those of the Extra-Peninsular Cretaceous and Tertiary coal-beds (table 13).

TABLE 13.—*Origin of Indian Coal raised during the years 1898 to 1903.*

YEAR.	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		TOTAL production.
	Tons.	*Per cent. of Total.*	Tons.	*Per cent of Total.*	Tons.
1898	4,301,147	*93·4*	307,049	*6·6*	4,608,196
1899	4,757,626	*93·4*	335,634	*6·6*	5,093,260
1900	5,785,114	*94·6*	333,578	*5·4*	6,118,692
1901	6,264,681	*94·4*	371,046	*5·6*	6,635,727
1902	7,083,179	*95·4*	341,301	*4·6*	7,424,480
1903	7,076,376	*95·1*	362,010	*4·9*	7,438,386
Average	*5,878,021*	*94·5*	*341,769*	*5·5*	6,219,790

The Gondwana coalfields.

The contribution from the Gondwana coal-fields in 1898 amounted to 93·4 per cent. of the total output for the year. This increased to 95·1 per cent. in 1903, whilst the average for the whole period of six years has been 94·5 per cent. Comparing 1898 with 1903, there has been an increased output in all the Peninsular Gondwana fields, except in the case of Singareni, where the rapid expansion which had been going on without interruption until 1902 was suddenly checked by a serious mining accident in June 1903, and a consequent drop in the year's output from 455,424 tons in 1902 to 362,733 tons in 1903. In the case of the Extra-Peninsular fields, there has also been an increase, though a much smaller one, in all the provinces, except in the Punjab, where the Dandot colliery in the Salt Range, which has been the chief producer, has been gradually failing (*cf.* table 17, page 35).

TABLE 14.—*Output of Gondwana Coalfields for the years 1898 to 1903.*

COALFIELD.	1898.	1899.	1900.	1901.	1902.	1903.
Bengal :—	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Daling . .	2,191	2,098	1,490	...	...	...
Daltonganj . .	...	...	707	3,881	19,352	33,557
Giridih . .	653,047	628,777	712,727	694,806	776,656	766,871
Jherria . .	749,988	1,007,236	1,710,757	1,946,763	2,420,786	2,493,729
Rajmahal . .	423	412	397	436	219	335
Raniganj . .	2,216,441	2,396,742	2,552,414	2,841,699	3,042,223	3,066,720
Central India :—						
Umaria and Johilla	134,726	164,569	164,489	164,362	171,538	193,277
Central Provinces :—						
Mohpani . .	22,472	23,596	39,612	43,046	43,645	31,443
Pench valley .	...	...	...	...	...	88
Warora . .	127,237	132,980	133,230	148,470	153,336	127,623
Hyderabad :—						
Singareni . .	394,622	401,216	469,291	421,218	455,424	362,733
TOTAL Gondwana beds .	4,301,147	4,757,626	5,785,114	6,264,681	7,083,179	7,076,376

Raniganj and Jherria.

Taking the Gondwana areas first, we find that the Raniganj field, which was the first to be developed, still holds the lead (see table 14), having turned out 41·2 per cent. of the total production for India in 1903. Jherria, further west in the Damuda valley, is, however, rapidly overtaking Raniganj since its railway connection to the capital by the East Indian line has been supplemented by a branch from the Bengal-Nagpur system. In 1897 Jherria contributed only 8·2 per cent. of the Indian output, whilst in the last year, 1903, the production of this field amounted to 33·5 per cent. of the total.

The coal from the Raniganj field is mainly derived from seams in the highest beds of the Damuda series, the lowest, or Barakar stage, being less developed in the exposures along the northern margin of the field. In the Jherria field the converse is the case: the uppermost stage has yielded poor coal, whilst in the Barakar series there are some eighteen well-defined seams, of which the upper eight seams include enormous supplies of good coal. The two classes of coal present a well-marked and constant difference in the amount of moisture they contain: the older, Barakar, coals, both in the Raniganj field and in Jherria, contain on an average about 1 per cent. of moisture, whilst the average for the younger coal of the Raniganj series is 3·8 per cent. in the lower seams, and nearly 7 per cent in the upper seams. There is a corresponding, but less marked, difference in the proportion of volatile hydrocarbons, which form a larger percentage of the younger coals than of those at lower stages in the Damuda series.

Giridih.

The small patch of coal-bearing Gondwana rocks near Giridih is practically divided between the Bengal Coal and the East Indian Railway Companies. The chief wealth of the field is stored in a 15-foot seam of good steam and coking coal near the base of the Damuda series. This coal has the following average composition:—

Fixed carbon	66·4
Volatile matter	24·4
Ash	9·2

The output of the field, which is controlled largely by the requirements of the railway company, has been rising gradually during the last six years from 660,665 tons in 1897 to 766,871 tons in 1903, and the remaining workable supplies probably do not exceed 77 million tons. A proposal for introducing modern methods of coke-making with a view to the recovery of the valuable bye-products is now being considered by the East Indian Railway Company.[1]

[1] T. H. Ward: Modern methods of coke-making. Rec. Geol. Surv. Ind., vol. XXXI, 92 (1904).

The other principal coal-fields being worked on the Peninsula are, Warora, Mohpani, and those of the Pench valley in the Central Provinces, Umaria in the Rewah State, and Singareni in the Nizam's Dominions.

Pench valley. In the Pench valley and the belt of related coal-bearing Gondwana rocks dipping under the Satpura range, only prospecting work has been done so far; but favourable results have been obtained by locomotive trials on samples of the coal, and the proximity of the fields to the great manganese-ore deposits, and (when connected by direct rail to Nagpur or Itarsi) to the markets of Bombay and the mills of the Deccan, will give these deposits an opportunity of developing whatever intrinsic merits they possess.

Mohpani. The coal-bearing rocks which dip under the Upper Gondwanas of the Satpura range re-appear near Mohpani in the Narsinghpur district, where they have just escaped total concealment by the Narbada alluvium. The Mohpani colliery has been worked since 1862 by the Nerbudda Coal and Iron Company, and, through various difficulties, has made very little progress. Between the years 1898 and 1903 the annual output from this colliery rose from 22,472 to 43,645 tons during the first five years, but a drop occurred in 1903, due to the final abandonment of the old mines and the development of work in the newly-discovered area two miles further west.

Warora. The Warora basin, about 62 miles south of Nagpur, in the Chanda district, has been worked since 1871 by the State. About half the coal raised, which averaged 137,146 tons a year for the years 1898 to 1903, has been taken by the Great Indian Peninsular Railway, the rest going to cotton mills and factories in Nagpur and other parts of the Central Provinces. The coal is liable to spontaneous combustion, and a large part of the field has been lost by fire and walled-off. The Warora colliery has been worked under distinctly greater natural difficulties than those usually met with in Bengal, but an examination of the chief results obtained by the present able management will probably be of value to those interested in Indian coal-mining. Table 15 shows the financial results of the past six years' working of the colliery. These results are shown graphically in relation to coal output on plate 3.

TABLE 15.—*Financial Results of the Warora Colliery during the years 1898 to 1903.*

YEAR.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on Capital.*
	£	£	£	
1898	39,719	28,247	11,472	*9·58*
1899	40,193	27,661	12,532	*10·96*
1900	40,507	26,939	13,568	*12·22*
1901	46,085	28,875	17,210	*15·90*
1902	46,669	29,267	17,402	*17·11*
1903	39,499	26,616	12,883	*13·16*

The average selling price of coal at Warora during the past six years has been Rs. 4-7 a ton, and the average cost of its production during the same period has been Rs. 3-1-5, of which a considerable fraction is due to charges for the sinking fund. This cost has been distributed as follows:—

	Annas
Mine Working Expenses—	
Superintendence	3·24
Coal-cutting	12·85
Underground haulage, including maintenance of shafts, roads and working ways, with repairs	9·87
Surface haulage, including lighting and maintenance of permanent way	1·25
Pumping	7·54
Ventilation	1·65
Staff-quarters and other buildings	0·42
Miscellaneous	1·52
Management and Office Expenses—	
Local Offices, Police, Medical and India Office charges	3·07
Sinking Fund charges	8·01
TOTAL .	49·42 annas.

The returns for labour at Warora, notwithstanding the difficulties arising from water and liability to spontaneous combustion, show that the system of mining adopted permits of a satisfactory output per person employed, whilst the deaths due to accidents have been reduced to a low rate. During the six years, 1898 to 1903, the average annual output of coal per person employed was 132 tons, whilst there were four deaths only during the period in which 822,876 tons of coal were raised, and the death-rate from mining accidents averaged 0·64 per 1,000 employed. Another three or four years will probably see the end of the Warora colliery, but, with the extension of the Wardha valley line southwards, the extensive deposits near Bellarpur will be opened up.

Singareni. The great belt of Gondwana rocks, near the north-west end of which Warora is situated, stretches down the Godavari valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda series in Bengal are found cropping up from below the Upper Gondwana rocks. One of these occurrences near Yellandu in the Nizam's Dominions forms the coalfield well known by the name of Singareni. The principal seam of coal, some 5 to 6 feet thick, being worked at the Singareni colliery, was discovered by the late Dr. W. King of the Geological Survey in 1872, but mining operations were not commenced until 1886, since when the output has rapidly risen to over 400,000 tons a year, although the production last year, 1903, showed a decline to 362,733 tons, owing to a serious subsidence in one of the workings (see table 14 and plate 2).

Coal-mining at Singareni has been accompanied by a heavier loss of life by accidents than in the general run of Gondwana fields. Table 16 shows the death-rate on this field compared with the rate in Bengal.

TABLE 16.—*Death-rate from Accidents at Singareni compared with Bengal.*

	—	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
SINGARENI.	Number of persons employed.	6,788	8,490	8,045	7,616	7,538	6,359	*7,473*
	Deaths from accidents .	9	8	9	12	17	29	*14*
	Death-rate per 1,000 employed.	1·33	0·94	1·12	1·58	2·25	4·56	*1·87*
	Death-rate in Bengal coal-fields	*0·45*	*0·52*	*0·60*	*0·53*	*0·53*	*0·85*	*0·58*

Umaria. The Bilaspur-Katni Branch of the Bengal-Nagpur Railway passes through the small coalfield of Umaria in the Rewah State, Central India. The quantity of workable coal in this field is estimated at about 24 million tons, and during the past six years the output has been gradually rising from 134,726 tons in 1898 to 193,277 in 1903 (see table 14, and plate 2). The four coal seams being worked vary from about 3 to 12 feet in thickness, and dip about 4° to the north-east. The mines were opened in 1882 under the direction of Mr. T. W. H. Hughes of the Geological Survey, and were controlled by Government until the 1st January 1900, when they were handed over to the Rewah State. Most of the coal raised is sold to the Indian Midland (Great Indian Peninsular) Railway, and a small quantity to the Bengal Nagpur Railway and other customers.

Cretaceous and Tertiary Coalfields.

The younger coals are nearly all of Cretaceous and Tertiary age, although some thin and poor seams of Upper Jurassic coal have been worked in Cutch. The Cretaceous beds occur in the Khasia and Garo hills in Assam, where they are found in small basins resting on the Archæan schists and gneisses. The Cretaceous coals of Assam are generally distinguished by the inclusion in them of nests of fossil resin, and this character was noticed in the coal recently discovered to the north of Shillong.[1]

Coal of Tertiary age is found in Sind, Rajputana, Baluchistan, along the foot-hills of the Himalayas, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones, though the richest deposits, namely, those in North-East Assam, are younger, probably miocene, in age. Of these Extra-Peninsular fields, the only ones producing coal are of Tertiary age. The output for each of these for the years 1898 to 1903 is shown in table 17 (page 35).

On the whole, the younger coals, which are being worked in Extra-Peninsular areas, differ from the Gondwana coals in containing a larger proportion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained,

[1] P. N. Bose: Report on the Um-Rileng coal-beds, Assam. Rec. Geol. Surv. Ind., XXXI, 35 (1904).

as for instance in Assam, with a remarkably low percentage of ash and having a high calorific value.

TABLE 17.—*Production of Tertiary Coal during the years 1898 to 1903.*

Province and field.	1898.	1899.	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Assam :—						
Makum	202,178	232,933	215,962	254,100	220,640	239,328
Smaller fields . .	1,367	807	774	...	456	...
Baluchistan :—						
Khost	10,662	11,689	17,664	18,431	25,982	36,444
Sor Range and Mach .	5	265	5,617	6,225	7,907	10,465
Burma :—						
Shwebo: Thingadaw .	6,975	8,105	10,228	12,466	13,302	9,306
Kashmir :—						
Ladda	...	...	...	...	1,138	999
Punjab :—						
Dandot	74,590	81,218	74,083	67,730	55,373	43,704
Other mines . . .	11,272	617	...	...	...	...
Rajputana :—						
Bikaner	...	...	9,250	12,094	16,503	21,764
TOTAL for Tertiary beds .	307,049	335,634	333,578	371,046	341,301	362,010

North-East Assam.

The most promising amongst these young coals is the group of occurrences in North-East Assam, one of which is now being worked by the Assam Railways and Trading Company, who commenced operations at Makum (27°15′; 95°45′) in 1881. The collieries are connected by a metre-gauge railway with Dibrugarh on the Brahmaputra river, which, being navigable, forms both a market and a means of transport for the coal. The most valuable seams occur between the Tirap and Namdang streams, where, for a distance of about five miles, the seams vary from 15 to 75 feet in thickness. The average dip is 40°, but as the outcrops in many places are several hundred feet above the plains, facilities exist for working the coal by adit levels. The average coal production of the Makum mines during the last six years has been 227,523 tons a year. The coal has the reputation of being a good fuel, and forms an excellent coke.

Shwebo district, Burma.

Coal occurs in various parts of Burma, and in the Shwebo district the annual output during the years 1898 to 1903 varied between 6,975 and 13,302 tons without signs of expansion. The only point worth adding to previously published accounts of the Burma coal is the fact that during the past year it has been definitely ascertained that in the Nammaw field, which is some 30 miles from the Mandalay-Lashio Railway line, the existence of seams of good coal, 10 feet thick, has been recently verified by the Geological Survey. This and the Lashio field, further north in the Northern Shan States, are likely to be of importance to the new railway lines in that area.

Baluchistan, Khost.

Possibly the most important of the coal deposits in the west occur in Baluchistan, where, however, the disturbed state of the rocks renders mining operations difficult, expensive, and often dangerous. Besides the small mines being worked in the Sor range, south-east of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost (30° 12′; 67°40′) on the Sind-Pishin Railway. The two seams being worked have an average thickness respectively of 26 and 57 inches, and the output has gradually risen from 10,662 tons in 1898 to 36,444 tons in 1903.

To the natural difficulties of the ground is added a serious scarcity of trained labour, and as a consequence the working results of these mines appear to be unfavourable when compared with the exceptional conditions existing on the Gondwana fields of Peninsular India. Table 18 (on page 37) shows the financial results of the undertaking, which is under the control of the North Western State Railway.

The output per person employed at Khost has averaged only 44 tons per annum during the past six years, and the difficulties of the work are further shown by the fact that the death-rate from mining accidents has been, in the same period, 23·2 per thousand persons employed; but of this serious loss of life, 47 out of a total of 64 deaths were caused on October 12th, 1899, by a fire in the Takrai mine. Besides the stratigraphical difficulties arising from working the Tertiary coal seams, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the danger of explosions by the large quantities of dust generally formed in working such friable coals.

TABLE 18.—*Summary of the Financial Results of Working the Khost Colliery during the years 1898 to 1903.*

YEAR.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on capital.*
	£	£	£	
1898	9,423	8,371	1,052	*25·00*
1899	10,482	11,334	−852	...
1900	16,290	14,443	1,847	*19·11*
1901	14,500	11,379	3,121	*22·77*
1902	18,509	17,266	1,243	*7·01*
1903	23,804	19,978	3,826	*17·02*

Dandot.

The coal which has been most worked in the Punjab is that long known to exist in the Jhelum district, on the Dandot plateau of the Salt range. The only valuable seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic limestone. The mines at Dandot and at Pidh, 3 miles to the north-east, have been worked for the North Western Railway since 1884. During the period under review, 1898 to 1903, the collieries have shown a decline in output, from a maximum of 81,218 tons in 1899 to 43,704 tons in 1903, and during the last two years the mines have been worked at a loss. The annual output of coal per miner employed at Dandot during the last six years has averaged only 42 tons, against about 75 tons turned out per man in Bengal; but notwithstanding the difficulties connected with mining in this area, the loss of life through accident has been as low, on an average, as 0·74 per 1,000 employés.

Bhaganwala.

The coal near Bhaganwala at the eastern end of the Salt range occurs in a seam of very variable thickness, in consequence of which widely discordant estimates have been made of the resources of the field. Between 1893 and 1898 the field was worked by the North-Western Railway, but the quality of the fuel was poor, and the collieries were worked at a loss. The output amounted to 11,272 tons in 1898, when arrangements were made to dismantle the colliery, which was closed on the 15th January 1899.

Mianwali district.

Some minor works, not beyond the scale of ordinary prospecting operations, have been conducted on the deposits of Jurassic coal in the Mianwali district. The deposits about 2 miles north of Kalabagh are estimated to contain about 72,000 tons of coal, of which less than 1,000 tons a year are extracted. More promising deposits of Tertiary coal occur in the Maidan range, 24 miles further west, but no mining in this locality has so far been attempted.

Bikaner.

A lignite of dark-brown colour, with included lumps of fossil resin, occurs in association with nummulitic rocks at Palana in the Bikaner State, Rajputana. In 1898 mining operations were started at a point where the seam was found to be 20 feet thick, and a branch line, 10 miles long, from the Jodhpur Bikaner Railway, has been constructed to assist the development of the colliery. The figures given in table 17 show a gradual increase of output since 1900, the returns for 1903 being 21,764 tons. The physical characters of the natural fuel form a drawback to its use in locomotives, but experiments recently made are said to show that satisfactory briquettes can be made in which the proportion of moisture is reduced, and the fuel made less vulnerable to atmospheric action.

Labour.

Coal-mining in India, from the point of view of labour, is quite ahead of all other forms of mining. The number of persons employed daily has averaged 84,805 for the years 1898 to 1903, but the returns for 1903 show 9,872 less workers than in 1902, although the output of coal has risen (see table 19). This difference is possibly in part due to a gradually increased precision in the system of making returns, and partly, no doubt, to the fact that the introduction of improved methods in mining is gradually increasing the average efficiency of the miner;

but the sudden rise to an output of 84 tons per person employed, shown in table 20 for the year 1903, is so much in excess of the Giridih return of 72 tons, that there is probably some fault in the returns made of persons employed.

Table 19 shows that 81·8 per cent. of the average number employed during the period have worked in Bengal coal mines, and that the changes elsewhere have been insignificant beside the rise in Bengal from 48,673 in 1898 to 74,538 in 1903.

TABLE 19.—*Number of Persons employed daily in Indian Coal-Mining during the years 1898 to 1903.*

PROVINCE.	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*	Per cent. of average total.
Assam . . .	1,439	1,444	1,350	1,210	1,293	1,255	*1,332*	1·56
Baluchistan . .	238	310	493	635	828	843	*558*	·66
Bengal . . .	48,673	58,130	72,790	79,620	82,545	74,538	*69,383*	81·80
Burma . . .	315	230	279	203	170	80	*213*	·25
Central India . .	1,931	2,354	2,214	2,126	1,723	1,670	*2,003*	2·35
Central Provinces .	1,711	1,852	2,104	2,220	2,337	2,071	*2,049*	2·41
Nizam's Dominions .	6,788	8,490	8,045	7,616	7,538	6,359	*7,473*	8·80
Punjab and Kashmir .	1,879	1,640	1,826	1,536	1,742	1,621	*1,707*	2·01
Rajputana . .	...	...	147	152	136	93	*(a) 132*	·16
TOTAL .	62,974	74,450	89,248	95,318	98,312	88,530	*84,805*	100·00

(*a*) Average of three years only.

Effect of coal-mining on the population.

In the parts of Bengal where coal-mining has especially developed, the changes in the population of certain revenue areas since the Census of 1891 have been quite remarkable. The Census of 1901 showed that in the Giridih sub-division of the Hazaribagh district, there had been an increase of 4·0 per cent., part of which, in the Ganwan and Koderma *thánas*, was due to mica-mining, whilst in the Giridih *thána* the increase in ten years was 8·8 per cent. In the Gobindpur sub-division of Manbhum district, which includes much of the Jherria field, the increase of population between 1891 and 1901 was 25·1 per cent., whilst in the Jherria *thána* itself the increase was 75·1 per cent., and in the adjoining *thána* of Topchanchi the increase, from the same cause, was 30·2 per cent.

Efficiency of the Indian collier.

It will not be surprising to those who know the habits of the Indian coal-miner to learn that the output per person employed is lower than in any part of the British Empire except in Cape Colony, where cheap native labour is largely employed. During the years 1901 and 1902 the outputs of coal per person employed in Indian mines were respectively 70 and 75 tons, whilst for the rest of the British Empire the corresponding figures were 281 and 285 tons (see table 21).

TABLE 20.—*Output of Coal per Person employed at Indian Collieries.*

	1898.	1899.	1900.	1901.	1902.	1903.
Number employed	62,974	74,450	89,248	95,318	98,312	88,530
Tons of coal raised.	4,608,196	5,093,260	6,118,692	6,635,727	7,424,480	7,438,386
Tons of coal raised per person employed.	73	68	69	70	75	84

Death-rate from accidents.

An important consideration, naturally, in every mining community is the risk to life involved in the occupation. As far as coal-mining is concerned in India, the industry, so far as it has progressed, has shown not only a very low death-rate from isolated accidents, but also a noteworthy freedom from disasters, which in European countries have done more, perhaps, than statistics to force special legislation for the protection of workers in "dangerous" occupations. Table 22 shows, for the period 1898 to 1903, the number of deaths from coal-mining accidents in India, compared with the amount of coal raised and the number of persons employed. It will be seen from this table that the average death-rate from such accidents has been 0·88 per thousand employed, which will compare favourably with the returns for any other country.

TABLE 21.—*Amount of Coal raised per Person employed at Coal Mines in the British Empire.*

COUNTRIES.	1901.			1902.		
	Persons employed.	Tons of coal raised.	Tons per person.	Persons employed.	Tons of coal raised.	Tons per person.
United Kingdom	792,648	219,046,945	276	810,787	227,095,042	280
New South Wales	12,191	5,968,426	490	12,815	5,942,011	464
Queensland	1,266	539,472	426	1,336	501,531	375
Victoria	827	209,329	253	1,303	225,164	172
British Columbia	3,974	1,460,331	367	4,011	1,397,394	348
Nova Scotia	7,663	3,625,365	473	8,062	4,366,869	542
Cape Colony	2,588	183,759	71	2,196	165,557	75
Natal	3,397	569,200	168	3,850	592,821	154
New Zealand	2,754	1,227,638	446	2,885	1,362,702	472
Transvaal	..	...	...	5,439	1,590,330	292
British Empire except India	**827,308**	**232,830,465**	**281**	**852,684**	**243,239,421**	**285**
India	95,318	6,635,727	70	98,312	7,424,480	75

In table 23 (page 43) the results for the rest of the British Empire for the years 1901 and 1902 (the latest years for which complete figures are obtainable) are compared with the corresponding years for India. It will be seen from this that India competes with Queensland for the lowest death-rate, and that the average rate for the rest of the Empire is 1·53 and 1·54 against 0·73 and 0·77 for India. The rate will also compare favourably with the principal foreign coal-mining countries: in Austria the rates for 1901 and 1902 were 1·39 and 1·60 per thousand respectively; in Germany 2·22 and 1·93; in Belgium 1·02 and 1·07; in France 1·21 and 1·09; in Holland 1·47 and 1·27; and in the United States 3·10 and 3·25.

TABLE 22.—*Production of Coal compared with Deaths from Coal-Mining Accidents in India.*

—	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
Deaths from coal-mining accidents	43	98	62	70	76	97	*74*
Thousands of tons of coal raised for each life lost . .	107	52	99	95	98	77	*84*
Lives lost per million tons of coal raised	9·3	19·2	10·1	10·5	10·2	13·0	*1·20*
Death-rate per thousand persons employed . . .	0·68	1·32	0·69	0·73	0·77	1·10	*0·88*

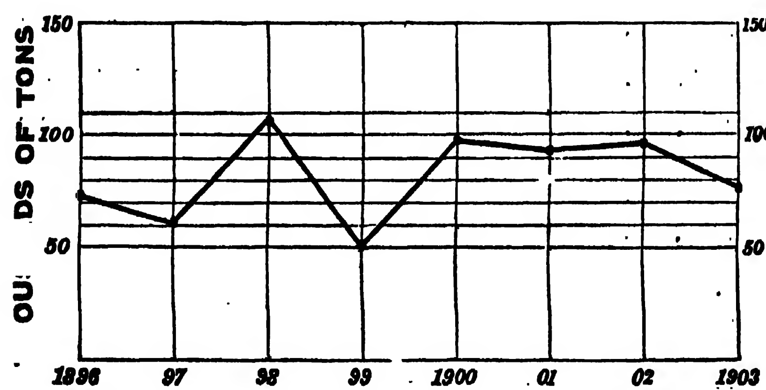


FIG. 8.—*Production of Coal per Life lost by Coal-mining Accidents.*

But the small output per person employed in India produces a far less favourable picture when we count the cost of a million tons of coal in lives lost by mining accidents. On this score it will be seen from table 23 that whilst in the years 1901 and 1902 the average numbers of lives lost per million tons of coal raised in the rest of the British

Empire were respectively 5·42 and 5·41, in India the loss in the same years came to 10·55 and 10·23. It will be noticed, however, that in India the number of persons employed in coal-mining is many times greater than in any part of the Empire, except the United Kingdom itself, where the large number of coal-miners, near 800,000, and the yearly output of more than 220 million tons of coal, together control and tone-out all the irregularities in the returns from the dependencies.

TABLE 23.—*Death-rate from Coal-Mining Accidents in the British Empire.*

	1901.				1902.			
	Number employed.	Deaths.	*Death-rate per 1,000.*	Deaths per 1,000,000 tons coal raised.	Number employed.	Deaths.	*Death-rate per 1,000*	Deaths per 1,000,000 tons coal raised.
United Kingdom.	792,648	1,075	*1·36*	4·91	810,787	1,005	*1·24*	4·42
New South Wales	12,191	17	*1·37*	2·85	12,815	105	*8·01*	17·67
Queensland .	1,266	1	*0·79*	1·85	1,336	1	*0·75*	1·99
Victoria .	827	4	*4·84*	19·11	1,303	1	*0·77*	4·44
New Zealand .	2,754	3	*1·09*	2·44	2,885	2	*0·69*	1·47
British Columbia	3,974	102	*25·67*	69·87	4,011	139	*34·65*	99·48
Nova Scotia .	7,663	14	*1·83*	3·86	8,062	19	*2·36*	4·35
Cape Colony .	2,588	4	*1·55*	21·77	2,196	4	*1·82*	24·16
Natal . .	3,397	43	*12·66*	75·54	3,850	16	*4·16*	26·99
Transvaal . .	...	...	...	...	5,439	23	*4·23*	14·47
British Empire except India .	**827,308**	**1,263**	**1·53**	**5·42**	**852,684**	**1,315**	**1·54**	**5·41**
India . .	95,318	70	*0·73*	10·55	98,312	76	*0·77*	10·23

The results for the coal-mines under the control of the Indian Mines Act of 1901 are slightly more favourable than for the total. For the three years during which the Act has been in operation the average death-rates from accidents at coal-mines under the Act have been as follows:—

1901	0·68	per 1,000.
1902	0·66	"
1903	0·84	"

Mining methods.

The almost universal practice in Indian coal-mines is to extract the coal on the system variously known as the "bord and pillar," "post and stall," or "stoop and room" system. Although this system in Europe is fast being superseded by the more economical "long-wall" method, yet, owing to the thickness of most of the Indian seams, it is not easy to devise any more suitable plan of working. It is undoubtedly wasteful, for the pillars form from 25 to 65 per cent. of the available coal, and at the present time, except in certain mines, where local-trained labour and efficient supervision are possible, their extraction is not even contemplated.

The strong roof so frequently found in the mines worked in Gondwana rocks, due, not only to the intrinsic strength of the rocks, but to the remarkable freedom from geotectonic disturbances on the Peninsula, adds a feature of strength and safety not at once fully appreciated by those who have gained their experience in countries without these advantages, or where the galleries are subject to the stresses of a greater overburden.

In the Giridih coal-field, the system of working thick seams at the East Indian Railway collieries permits of the removal of over 90 per cent. of the coal. As the system here carried out has been subject to careful criticism by English colliery experts, and as it has been shown that the system is perfectly safe under the efficient standard of management and discipline observed at Giridih, workers in other fields are recommended to study the account given by Mr. T. Adamson in his paper on the "Working of a thick coal-seam in Bengal," (*Trans. Min. and Mech. Engineers*, vol. LII, p. 202, 1903).

The system described by Mr. Adamson has been worked for the last twelve years in the Railway Company's collieries at Giridih without a fatal accident being caused by it, but the sandstone roof is an unusually strong one and the coal is free of gas. During the past six years, 1898 to 1903, the average death-rate from accidents of all kinds in these mines has been only 0·40 per thousand persons employed.

The figures given in table 23 for other coal-mining countries will give an idea of the remarkable degree of efficiency in management which this figure indicates.

In the Makum field a highly inclined seam, 75 feet thick, is worked on a modification of the South Staffordshire system of "square work." The coal is removed in two, or sometimes three, sections, the top section being removed first, and a parting of stone and coal being left untouched between each pair of sections. In the Dandot and Khost mines, thin seams are worked in one operation, on a modified "long-wall" system.

Gold.[1]

Comparison with other countries.

India, as shown in table 24, occupies the sixth or seventh position amongst the leading gold-producing countries of the World. The total Indian output is nevertheless comparatively insignificant, aggregating no more than 3½ per cent. of the World's annual supply.

TABLE 24.—*Production, in Ounces, of the Chief Gold-producing Countries for the years 1897 to 1902.*

COUNTRIES.	1897.	1898.	1899.	1900.	1901.	1902.
United States	2,864,576	3,148,642	3,391,196	3,781,310	3 805,500	3,870,000
Australasia (*a*)	2,539,491	3,013,763	3,831,937	3,568,279	3,719,103	3,989,083
Canada	291,583	662,796	1,018,371	1,350,176	1,183,465	1,003,447
Transvaal	2,744,010	3,777,009	3,529,826	348,760	238,991	1,704,410
Russia	1,042,017	1,196,634	1,159,214	1,072,434	1,253,592	1,183,379
India	390,595	418,944	456 020	512,985	532,126	517,639
Mexico	344,518	398,487	448,832	455,204	499,725	546,373
China	321,296	21,296	321,510	208,031	145,138	193,517
Korea	52,927	55,432	70,954	87,882	111,272	217,706
Brazil	70,736	76,613	107,644	127,820	133,636	146,898

(*a*) Includes the six States and New Zealand.

[1] This note on gold has been prepared mainly by my colleague, Mr. J. Malcolm Maclaren, B.Sc., F.G.S.

Table 25 shows the provincial production for India. In 1903 no less than 99½ per cent. of the Indian output was returned by Mysore. Three-fourths of the remainder was derived from the Nizam's Dominions, leaving only ·18 per cent. as the produce of districts directly under British administration.

TABLE 25.—*Value of Gold produced during the years 1898 to 1903.*

	1898.	1899.	1900.	1901.	1902.	1903.
	£	£	£	£	£	£
Mysore	1,575,966	1,678,463	1,879,085	1,923,081	1,969,442	2,283,999
Nizam's Dominions . .	11,620	33,335	9,375	...	...	14,505
Burma	4,115	4,386	3,327	7,606	5,894	3,988
Madras	10,993	1,261	17	...	...	...
TOTAL (*a*) .	1,602,694	1,717,445	1,891,804	1,930,687	1,975,336	2,302,492

(*a*) Exclusive of small quantities obtained by river-washing in various provinces for which accurate returns are not available.

Development of the Kolar Field.

The produce of the Mysore State is solely derived from the Kolar district, and from a single vein or reef in that district—a reef averaging only some four feet in thickness, and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wainad gold "boom" of 1878-82, several companies with huge capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed the greater portion was devoted to purchase money, and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped, and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies floated with such extravagant hopes in 1881-2 were moribund in 1885, and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the disposition of the auriferous chutes.

By 1887 the adjacent companies had resumed operations, and since then the history of the field has been one of uninterrupted progress and success. The deepest workings are now somewhat more than 3,000 feet below the surface, and the reef shows, at that depth, little diminution in the value or in the width of the quartz.

Neither mining nor milling offers any serious obstacles on this field. In the former the necessity for heavy timbering and filling to keep the roadways open is perhaps the most serious. The ore is not refractory, and yields its gold to a simple combination of amalgamation and cyaniding.

During the six years under review the annual tonnage crushed has been increased by 62 per cent., from 337,636 tons in 1898 to 546,752 tons in 1903. The gold yield has not shown a corresponding advance, rising only from £1,575,966 in 1898 to £2,284,000 in 1903, an increase of 44·3 per cent. The divergence between the increase of tonnage crushed and the increase of yield therefrom is due to the fact that, with the economies in mining and milling indicated by experience, it is now possible to profitably crush low-grade quartz that ten years ago must have been left in the vein.

For the six years under review the value of gold extracted was £11,310,038, or 60 per cent. of the total value (£18,687,818) extracted in the 21 years since the commencement of work under European supervision. With the increase in output dividends have also increased, rising from £739,114 in 1898 to £1,019,347 in 1903, or an increase of 38 per cent. The total dividends paid during the six years were £4,988,793, or 60 per cent. of the dividends (£8,287,071) paid since 1882, indicating that dividends and output have advanced *pari passu.*

The above dividends have been paid wholly by five companies situated on the line of the Champion reef—the Mysore, Champion Reef, Ooregum, Nundydroog, and Balaghat. A considerable amount of exploratory work has been done by other companies on the Kolar field and elsewhere in Mysore, but hitherto without profitable result.

Of the improvement schemes which will make greatly for the reduction of working expenses, and, to that extent, for the prolongation of the life of the Kolar field, the introduction of electric power from the Cauvery falls is probably the most important. This work was commenced about July 1902, and has since uninterruptedly supplied a little more than 4,000 horse-power to the various mining and metallurgical works. The power is transmitted from the Cauvery Falls over duplicate lines 91½ miles long. The cost to the companies for the first year was

£29 per horse-power, and for succeeding years the cost will be £18. The success of the scheme has led to its enlargement, and works in progress will enable the Mysore Government to materially increase the power available for consumption.

Table 26 shows the various statistics for the Kolar field for the period under review.

TABLE 26.—*Statistics o} Production in the Kolar Gold-field.*

YEAR.	Tonnage crushed.	Ounces, bar gold.	Value of gold extracted.	Dividends paid.	Royalty.
			£	£	£
1898 . .	337,636	412,966	1,575,966	739,114	78,009
1899 . .	339,526	446,397	1,678,464	762,600	83,154
1900 . .	401,687	509,272	1,879,085	767,586	93,619
1901 . .	450,272	530,142	1,923,081	874,158	95,219
1902 . .	499,664	533,492	1,969,442	825,988	97,365
1903 . .	546,752	597,884	2,284,000	1,019,347	(a)113,200
TOTAL . .	2,575,537	3,030,153	11,310,038	4,988,793	560,566

(a) Estimated.

Total value of gold produced from 1882 to 1903 inclusive ...	£ 18,687,818	11	3
" of dividends paid " " ...	£ 8,287,071	7	2
Approximate value of Royalty paid to Mysore Government from 1882 to 1903 inclusive	£ 926,334	13	2

The work of the field is carried on by Europeans, Eurasians and Natives in the following proportions, calculated from the number employed during an average year (1902):—

	Per-cent.
Europeans (including Italian miners)	2·05
Eurasians	1·58
Natives: men	89·83
Natives: women (employed only on the surface) . .	6·54

The following table indicates the risks attendant on mining in the Mysore State:—

TABLE 27.—*Showing Fatal Accidents in Mysore Mines for the years 1898 to 1903.*

YEAR.	No. of persons employed.	Death-rate per 1,000 employed.	Death-rate per 100,000 tons quartz crushed.	Death-rate per £100,000 worth of gold obtained.
1898 . .	21,597	2·45	15·70	3·36
1899 . .	21,093	1·80	11·19	2·26
1900 . .	24,587	2·61	15·68	3·35
1901 . .	25,060	2·99	16·65	3·90
1902 . .	26,268	2·21	11·58	2·90
1903 . .	27,355	2·52	11·27	3·02
Average .	*24,326*	*2·43*	*13·67*	*3·13*

Outside the Mysore State the only gold quartz mine producing gold at the end of 1903 was the Hutti (Nizam's) mine situated at Hutti in the Lingsugur district of Hyderabad. This company is an offshoot of the Hyderabad (Deccan) Company and was floated in 1901. Crushing with 10 head of stamps was commenced in February 1903, and 3,414 ounces were returned for that year. This result has been considered so promising that the crushing power is being doubled. The workings of this mine give evidence of the remarkable mining skill of the ancients, the auriferous chute having here been followed downwards to a depth of no less than 540 feet.

Nizam's Dominions.

Another offshoot of the Hyderabad (Deccan) Company was formed in 1898 to work the adjacent mines of Wundalli, and during 1899 crushed 18,790 tons of quartz for a yield of 7,822 ounces. The yield of the Nizam's territory during 1898-99-1900 was almost exclusively the produce of the Wundalli Company. Work was, however, stopped at these mines towards the middle of 1900.

The yield shown from the Madras Presidency was derived from the Mysore (Kangundi) mines in the Kangundi zemindari of North Arcot. Work commenced

Madras Presidency.

here in 1893, and was continued with varying success until 1900. The highest yield obtained was that for the year 1898, *viz.*, 2,854 ounces.

Burma.

During the period under review the only other reef-mining of importance was carried on at the Kyaukpazat mine near Wuntho, in Upper Burma. This mine yielded, in 1898, 1,120 ounces, and maintained, and indeed increased its yield until 1902, when 1,984 ounces, valued at £7,606, were produced. This yield, however, formed merely another example of the general rule that auriferous deposits in andesitic rocks are extremely uncertain in extent and in richness. The pay chute was lost in 1903, and after some exploratory work the mine was closed down.

Alluvial gold-washing is carried on in many places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. Returns for 1903 show, however, that 106 ounces of alluvial gold were obtained from the Ladhaki wazirat of the Jammu and Kashmir State. This amount may perhaps be fairly taken as an indication of the annual yield from this portion of the Upper Indus.

Dredging for alluvial gold above Myitkyina on the Upper Irawadi was commenced about November 1902, with a dredger capable of dealing with 10,000 tons a week. The whole of the season (until June 1903) was spent in prospecting the river bed. Five or six spots were thus tried, and the results were considered to be sufficiently satisfactory to warrant an increase of dredgers.

During the past two years surveys of the auriferous deposits of India have been in progress. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the rains. The greater possibilities of dredging on the Irawadi appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

Graphite.

Mode of occurrence.

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, which is but a continuation of the charnockite series and associated rocks of South India. Similar geological occurrences of graphite are found in Coorg, and in the hill tracts of Vizagapatam and adjoining State of Kalahandi. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[1] a conclusion in agreement with its occurrences in South India.[2]

Production.

Prospecting for graphite has been attempted in the Godavari district, Madras Presidency, and in the Ruby Mines district in Upper Burma, but the only progress made in mining has been in the Travancore State. Regular returns were not available before 1901, but the following figures are returned for Travancore for the remaining three years of the period under review:—

1901	2,490 tons.
1902	4,575 "
1903	3,394 "

Iron.

Notwithstanding the fact, very widely published, that rich deposits of iron-ore occur in India, only one attempt to manufacture iron on European lines has been so far successful, and as it is doubtful if the ores are sufficiently valuable to bear the cost of transport to Europe, no attempt has been made to raise Indian iron-ore for export.

The production of ore is thus confined to that used by the Bengal Iron and Steel Company in its works at Barakar, and the smaller quantities, for which accurate returns are not obtainable, used in the numerous small native furnaces still surviving in parts of Central India, the Central Provinces, Madras, Mysore, and Rajputana. Iron-ore is also used in small quantities in the steel furnaces at the East Indian Railway Company's workshops, Jamalpur.

[1] Die Graphitlagerstätten der Insel Ceylon. Abhand., d. k. Bayer., Akad., 1901, xxi, 279—335.

[2] Holland: The Charnockite series, Mem. Geol. Surv. Ind., XXVIII, 1900, 126; and the Sivamalai series, Mem. Geol. Surv. Ind., XXX, 1901, 174.

The figures returned for Bengal, in which most of the ore used at Barakar is raised, are given in table 28.

TABLE 28.—*Iron-ore raised in Bengal during the years 1898 to 1903.*

YEAR.	Quantity.	Value.	Value per ton.
	Tons.	£	Shillings.
1898	41,854	7,006	3·35
1899	52,000	6,333	2·44
1900	57,000	7,333	2·57
1901	57,800	8,352	2·89
1902	76,056	11,287	2·96
1903	61,355	9,717	3·17
Average	57,678	8,338	2·89

Up to the present the Barakar Iron and Steel Company has manufactured pig-iron only, of which with two blast furnaces they have turned out about 35,000 tons of pig-iron a year. But a third blast furnace is now in course of erection, and arrangements are complete for starting the manufacture of steel.

Outside Bengal there is very little done in the way of iron-manufacture. The Central Provinces show the largest returns, varying from 2,400 to 4,800 tons, and there is also a sensible industry surviving in Bijawar, Panna, and Orchha, amongst the Central India States, as well as in Mysore and in parts of the Madras Presidency.

Steel is made, both in the form of ingots by the carburization of wrought-iron in crucibles, and, on a much smaller scale, by the decarburization of cast-iron shot in a small open hearth.

Jadeite.

The mineral jadeite, like the jade with which it is often confused, is especially prized by the Chinese, and the quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into South-West China, whilst most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and China. The following table shows the extent of this export trade:—

TABLE 29.—*Exports of Jadestone from Burma to the Straits Settlements and China.* (*a*)

YEAR.	Weight.	Value.	Value per cwt.
	Cwts.	£	£
1897-98	4,036	41,780	10·35
1898-99	4,532	42,120	9·29
1899-00	3,130	58,955	18·83
1900-01	4,531	46,377	10·24
1901-02	3,015	31,713	10·52
1902-03	4,220	47,676	11·06
Average	*3,911*	*44,770*	*11·45*

(*a*) Overland trade and exports *viâ* Rangoon combined.

Value of jade. Amongst prehistoric relics found in various parts of the World, both jade and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers, and to whom the different varieties of both minerals, and possibly some others, are known under the generic name *Yu-esh.* The softer, serpentinous mineral bowenite passes on the North-West Frontier under the name of *Sang-i-yeshm*, and though its characters are unmistakeably distinct from those of jade and jadeite, it is evidently regarded as a poor variety of jade.

Mode of occurrence. Some jadeite, and often the best material, is obtained as pebbles in the gravels of the Uru river, a tributary of the Chindwin, but most of the material is obtained by quarrying near Tammaw (25° 44′; 96° 14′) in the Mogaung subdivision of the Myitkyina district, Upper Burma. At this locality the jadeite forms a layer in the dark-green serpentine, against which, on a fresh surface, it stands in striking contrast on account of its lighter colour. The serpentine is apparently intrusive into miocene sandstones, and the jadeite must have been separated as a primary segregation from the magma.

Composition.

There is a general external resemblance between jadeite and jade, or nephrite as it would be more appropriately called, but mineralogically the two are quite distinct. Jadeite is essentially a silicate of soda and alumina, Na_2O, Al_2O_3, $4SiO_2$, with the crystallographic characters of the pyroxene group. Jade is a silicate of lime and magnesia, CaO, $3MgO$, $4SiO_2$, with the essential characters of a hornblende. Their crystallographic characters sufficiently distinguish them in microscopic sections, but in hand-specimens jadeite can be distinguished by its superior hardness and higher specific gravity, as well as by its greater fusibility.

Jadeite occurs in masses of closely interwoven crystals, a structure which gives rise to its great toughness. The purest, though not the most valued, forms are white in colour, but more often there are various shades of green, and, in the case of stones found embedded in the laterite of Upper Burma, there is a red staining often extending to considerable depths in the pebbles, and, in the eyes of the Chinese purchaser, greatly increasing the value of the mineral. The white jadeite with emerald-green spots, caused by the presence of chromium, is also valued greatly for the carving of ring-stones or bracelets.

Prices.

The prices paid for rough stones vary too greatly to permit of an average figure being given, but the export values declared give an idea of the value of the stone: the value so determined has averaged £11·9*s*. per cwt. during the last six years.

No jade (nephrite) of the kind which would be regarded as a marketable mineral is known in India. A mineral having the essential composition, and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkistan for many centuries.[2]

Magnesite.

In South India there are numerous occurrences of the ultra-basic igneous rocks in which olivine is an abundant constituent, and at

[1] F. R. Mallet, Rec. Geol. Surv. Ind., v, 22.

[2] *Cf.* papers quoted by Mallet in Manual, Geol. of Ind., part iv, 1887, p. 85.

several places these highly magnesian silicates have been decomposed with the formation of magnesite of great purity. The largest and best known of these occurrences is near Salem, where the area occupied by the white magnesite veins has been named the "Chalk" hills.

Prospecting operations have been in progress in this area for some years, but the industry may now be described as having passed into the mining stage, and on account of the remarkable purity of the mineral being raised it is expected to command a special price for the preparation of the refractory bricks used for the linings and hearths of steel furnaces, and for lining the fire-bricks of the electric calcium-carbide furnace. The production so far has been small—amounting to 3,540 tons in 1902 and 825 tons in 1903—but work is now being organized on a larger scale.

Manganese-ore.

Production.

The mining of manganese-ore has sprung-up within the last 12 years, and has developed so rapidly that India now takes second place amongst the manganese-producing countries in the World, with an output during the year 1903 of 171,806 statute tons. Table 30 shows the output for each of the past six years and figure 5 (page 13) shows the progress of the mining industry since its commencement.

TABLE 30.—*Production of Manganese-ore for the six years 1898 to 1903.*

YEAR.	Madras.	Central Provinces.	Central India.	TOTAL.	
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Metric Tons.*
1898 . .	60,449	...	...	60,449	*61,419*
1899 . .	87,126	...	...	87,126	*88,524*
1900 . .	92,458	35,356	...	127,814	*129,865*
1901 . .	76,463	44,428	...	120,891	*122,831*
1902 . .	68,171	89,608	...	157,779	*160,311*
1903 . .	63,452	101,554	6,800	171,806	*174,563*

Provincial division.

It will be seen from this table that the mining of manganese-ore was confined to the Madras Presidency until 1899, after which the rich deposits in the Central Provinces were attacked, and are now, notwithstanding their great distance from the coast, providing the chief part of the mineral exported to Europe and America.

Production of foreign countries.

The statistics published by different countries cannot be directly compared, as different definitions of a manganese-ore are followed. According to the rulings of the United States Treasury before 1899, a manganese-ore was so-called only when it carried 50 per cent. of the metal; but in 1899 lower grades were admitted if they contained less than 3 per cent. of iron, and the recognised lower limit is now 44 per cent., those below this grade being generally manganiferous iron-ores. The statistics for 1902 show, in the case of the United States, a total production of 901,214 statute tons of manganiferous iron-ore, but only 16,477 tons came within the Treasury definition of a manganese ore, whilst in the same period as much as 235,576 tons of the 50 per cent. ore was imported. Of the countries which supplied this amount, Brazil contributed 102,550 tons, India 64,170 tons, Cuba 36,294 tons, Turkey 12,609 tons, and Spain 10,464 tons.

Table 31 (on page 57) shows the chief producers of manganese-ore in the World. Of these Brazil has developed as rapidly as India, its output having risen from 14,710 tons in 1896 to 156,269 tons in 1902. Spain, the next producer, for many years turned out over 100,000 tons, but since 1900 has been declining rapidly. Russia has always been the leading producer, the chief source being beds of pure ore interstratified with eocene sands and shales in the province of Kutais.

Distribution of manganese-ore in India.

The mineral is now assuming such importance that it will perhaps be useful for those who are following the developments to put on record a sketch of the distribution in India of deposits considered to be of possible value.

In the Central Provinces, where mining is at present most active, the principal occurrences are in the Ramtek tahsil of the Nagpur district, where in some 17 different villages quarrying operations are being actively carried on. In the north-west part of the Bhandara district there are 14 localities known to contain manganese-ore, and a certain amount of work is in progress. In the Balaghat district 10 occurrences are known in the west of the district, whilst mining is being carried on near the town of Balaghat, and on another large deposit at Ukua in the Behir tahsil. In Chhindwara manganese-ore is known at 11 localities in the Sausar tahsil, whilst the mineral has long been known near Gosalpur and Sihora in the Jabalpur district. The ore has also been reported from the Khairagarh and Kalahandi States.

TABLE 31.—*Principal sources of Manganese-ore, and latest reported productions.*

COUNTRY.	Year.	Production.	COUNTRY.	Year.	Production
		Tons.			Tons.
Russia . . .	1900	884,200	Cuba (Exports) . .	1902	39,628
India	1903	171,806	Chili (Exports) . .	1901	31,477
Brazil (Exports) . .	1902	156,269	France . . .	1901	22,300
Spain . . .	1902	62,044	United States . .	1902	16,477
Turkey (Exports) .	1902	50,000	Japan . . .	1901	15,858
Germany . . .	1902	49,812	Greece . . .	1901	14,166

The deposits in the Central Provinces possibly belong to the same group of rocks which further to the south-east were first worked for manganese-ore in the Vizianagram State, and the intermediate jungle-covered country, which is very little known, will possibly yield further occurrences of the ore on more systematic exploration. In other parts of the Madras Presidency the ore has been reported in the Kallikota State, in the Ganjam district, and in the Sandur hills of Bellary.

One occurrence has been recorded in the Gwalior State, and one is now being worked in Jhabua, from which 6,800 tons were turned out in 1903, whilst there are several localities at which poor ores are found in the Dhár forest.

On the Bombay side, manganese-ores have been found at several places around Mahabaleshwar and Satara; in the southern part of Belgaum district; in Bijapur; near Jambughora in Rewa Kantha; and in the Dharwar district where prospecting operations are in progress. If the deposits in Dharwar and Belgaum approach those in the Central Provinces in quality, they will, on account of their proximity to the coast, develop very rapidly. Manganese has been reported also in the Tavoy and Mergui districts of South Burma, in the Nizam's Dominions, and in the form of manganiferous iron-ore near Chaibassa in Chota Nagpur.

Mode of occurrence, Nagpur area.

In the Nagpur area the manganese-ore occurs as lenticular masses and bands in the quartzites, schists, and gneisses, and as regards origin appears to have been formed at least partly, by the alteration of rocks composed of manganese-garnet, with which the mineral rhodonite, a manganese pyroxene, is often associated. Consequently the ore is frequently found to pass, both laterally and along the strike, into partly altered or quite fresh spessartite-quartz rock, or rhodonite-spessartite-quartz rock.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions, and their disposition as irregular lenses along the strike of the enclosing schists naturally influences the miner in laying out the boundaries of his "claims." A deposit near Balaghat is 1¾ miles long; at Manegaon in the Nagpur district the ore-body is 1½ miles long; whilst at Thirori in the Balaghat district it is nearly 6 miles in length. As examples of great breadth may be quoted Kándri, 100 feet thick, of pure ore, and Rámdongri, 1,500 feet of ore and unaltered spessartite (manganese-garnet) rock. The depth of these ore-bodies is quite unknown, as the so-called mining has so far passed little beyond the quarrying stage, and the question of possible exhaustion does not enter into the calculations of the present owners.

Composition.

This Nagpur ore is typically a mixture of braunite, and psilomelane, sometimes, though, entirely braunite—a hard, compact, pure ore, ranging well over 51 per cent. of manganese. The average material now being raised ranges between the following limits on analysis :—

	Per cent.
Manganese	51—54
Iron	5—8
Silica	5—9
Phosphorus	0·05—0·12
Moisture	usually below 1·0

The Vizianagram ore occurs under geological conditions apparently resembling those of Nagpur, though the enclosing rocks are sometimes too decomposed for precise petrological determination. There is another mode of occurrence in the Nagpur district, the ore occurring as nodules in crystalline limestone associated with piedmontite, and in places where there has been a dwindling of the limestone through water-action, these nodules of ore have accumulated in layers of a size which might be worth working. Occasionally in cavities in this limestone beautiful pyrolusite crystals are found.

Being near the coast, and consequently free of the tax of railway freight, it is possible to export a lower grade of ore from Vizianagram than from the Central Provinces. The ores shipped from Vizianagram show, according to Mr. H. G. Turner (*Journ. Iron and Steel Inst.*, 1896, I, 160) the following range of composition :—

Manganese	45—50 per cent.
Iron	7—13 „
Silica	2— 5 „
Phosphorus	0·12— 0·27 „
Moisture	1·10— 1·80 „

Manganese-ore occurs under different conditions in the Jabalpur district, where it is found in the Dharwar-like schist series which forms a belt with a maximum width of 7 miles stretching for 20 miles in a N.E.—S.W. direction. The rocks in this belt are various quartzites, phyllites, and schists, including hematite-schists and jaspers. The hematite-schists are slightly manganiferous and are often capped by a secondary deposit of limonite, in which psilomelane has formed into irregular nodules. Pyrolusite and psilomelane also occur in this district, sometimes occupying cavities in a siliceous breccia which is rather common.

Jabalpur.

The manganese-ore occurring in the neighbourhood of Mahabaleshwar forms irregular nodules distributed through the laterite cover on the Deccan Trap, and the nodules are formed presumably by concentration of the residue from the action of meteoric waters on the basaltic rocks.

Mahabaleshwar.

For use in steel-making, manganese-ores should contain not more than 0·15 per cent. phosphorus nor more than 10 per cent. of silica. Under conditions laid down by the Carnegie Steel Company, ores containing less than 40 per cent. manganese and more than the above-mentioned quantities of phosphorus and silica may be rejected at the option of the

Valuation of manganese-ore.

buyer. Deductions from the scheduled price per unit are made also for every 1 per cent. of silica above 8 per cent. and for each 0·02 per cent. of phosphorus in excess of 0·1 per cent. Steel manufacturers pay an additional price per unit of iron present in the ore.

TABLE 32.—*Variation in the Price of Manganese-ore c. i. f. at United Kingdom Ports.*

Date.	50 per cent. Mn. and upwards.	47—50 per cent. Mn.	40—47 per cent. Mn.
	Pence per unit.	Pence per unit.	Pence per unit.
January 1898	9—12	8½—11	7½—10½
July 1898	9—12	8½—11	7½—10½
January 1899	10—12½	9—11	7½—10½
July 1899	12—14	10½—11½	8—10
January 1900	13—15	12—13	10—12
July 1900	13½—15	11½—12½	10—12
January 1901	12—14	11—12	10—11
July 1901	10½—11	9—10	—8
January 1902	9½—10½	9—9½	8—9
July 1902 . . .	9½—10½	9-9½	8—9
January 1903	10—10½	8½—9	7½—8½
July 1903	10—10½	8—9	7½—8½
January 1904	9—9½	8—9	6—8

Prices.

The prices paid for manganese-ore carrying over 50 per cent. of the metal, delivered at United Kingdom ports or at New York, ranged between 9 and 10 pence per unit at the end of 1903. Thus, an ore with 52 per cent. manganese would be valued at $\frac{52 \times 9}{12}$ = 39 shillings a ton. Table 32 (page 60) and the following diagram (figure 9) show the recent variations in the prices of ore of different grades :—

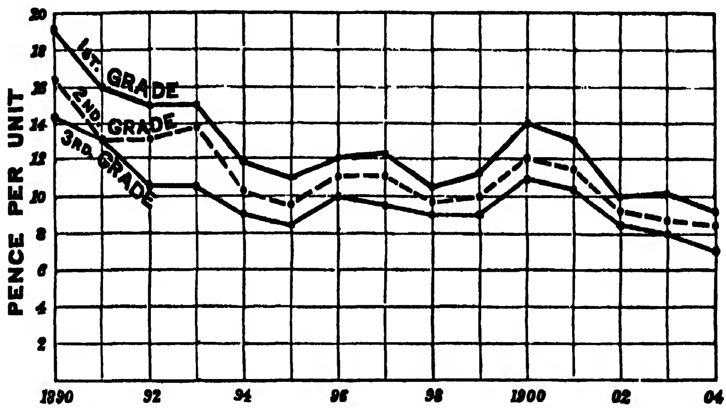


FIG. 9.—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890.*

Economic considerations.

Owing to the distance of the chief deposits from the sea-board—amounting in the case of the Central Provinces to about 500-600 miles—and the heavy freight charges to Europe and America, only the high grades of ore can be touched. Ores which would be considered valuable within range of a steel-making centre are rejected in India, and the result is a regretful waste of the natural resources, which will continue until there is a demand in the country for ferro manganese and facilities for its manufacture. As the ore sent out of India ranges a little over 50 per cent. of manganese, the metal for which it is valued is charged with nearly double freight; but the present owners of mines have so far sunk comparatively little capital, and the so-called mines are mere open quarries worked by the assistance of no expensive plant; there is thus no present inducement for husbanding resources, and there will probably be no attempt, either to manufacture ferro-manganese from low-grade ores, or to make steel, before the inevitable decline in the mining industry takes place. There is now an apparent haste to make the most of the present circumstances, and as the Indian and Brazilian outputs have already affected the market, there is a very evident fear of depreciation in prices, and consequent curtailment of the life of the industry; for the export of manganese-ore will cease to be profitable long before the natural stocks of higher grades of ore are exhausted—when, in fact, quarrying passes into mining, and the simple excavation of rich ore now in sight in great quantities gives place to the more expensive process of selection. However, by all accounts and all appearances, there is yet a fair future before the present owners of manganese-ore quarries, and the wonder is, not that manganese-ore mining has developed so greatly in India, but that such rich deposits could have remained so long prominently exposed and yet untouched, as attention was directed to the best of them many years ago.[1]

One cannot help the feeling of regret that the whole industry is at present equivalent to a heavy loss to the country. The ore exported is worth perhaps Rs. 30 a ton in the country to which it is sent: this country gets out of it merely the margin left after paying the heavy freight charges, and possibly Rs. 15 a ton can be regarded as the profit to India, divided between the railways, the miners and the owners of the land. At the same time, India has to pay the foreign manufacturer's profits and the cost of return carriage for the manganese brought back in the form of steel. If a flourishing steel-manufacturing industry existed in the country, much of the manganese would be retained in India, and the lower-grade ores also would be economically developed. As it is, our manganese-ore is being exported to the three great steel-producing countries—England, United States, and Germany. The exports to Holland and Belgium shown in table 33 are in part for transmission to Germany, whilst the consignments sent to Egypt were booked to Port Said to await orders for delivery to ports further west.

Uses of manganese-ore.

It is only, however, within recent years that the demand for manganese in steel-making has grown so rapidly. Manganese-ore was formerly used in the chemical trade in various ways, but mainly for the production of the chlorine necessary to manufacture bleaching powder: it was then valued especially for its content in oxygen, in which respect the Indian braunite is inferior to pyrolusite. Now the conditions are reversed, and the ore being valued mainly on account of its manganese content, the sesquioxide, in braunite, which predominates in the Indian deposits, is more valuable than the dioxide, pyrolusite.

[1] V. Ball, Manual of the Economic Geology of India, 1881, 329.

TABLE 33.—*Distribution of exported Indian Manganese-ore for the years 1897-98 to 1902-03.*

COUNTRIES.	1897-98.	1898-99.	1899-00.	1900-01.	1901-02.	1902-03.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
United Kingdom	54,279	51,931	63,175	86,269	65,150	95,540
Belgium . .	...	...	5,350	13,300	...	1,000
France . .	...	...	...	5,850	...	...
Germany . .	...	...	...	...	11,300	10,734
Holland . .	...	...	8,350	16,500	...	5,050
Egypt . .	...	...	...	3,400	15,000	...
United States .	24,550	10,900	18,350	5,350	41,720	42,950
TOTAL .	78,829	62,831	95,225	130,669	133,170	155,274

Mica.

Incomplete returns for production.

The returns of production for mica grossly understate both quantity and value, as both are below the export returns. As the only mica on which royalty is charged is that raised in Government land, and as many mica miners have mines in both Zemindari and Government land, there are obvious reasons for understating the production, and, besides this fact, the flourishing industry of stealing mica diminishes the returns for production without affecting the export figures.

Exports.

A considerable quantity of mica of the poorer grades is consumed in the country for ornamental and decorative purposes, and a small quantity of the larger sheets is used for painting pictures on in various parts of the country. As far as the figures for *quantity* are concerned, therefore, the exports cannot be accepted as an approximate expression of the production; but as regards *value,* the export returns may be accepted as a closer approach to the figures which should express production.

Variations in value.

From table 34 it will be seen that, during the years 1897-98 to 1902-03, the mica exported averaged 19,173 cwts., and had an average annual value of

£77,613, or £4·05 per cwt. The variations in yearly value reflect a serious change in the trade which occurred in 1899. The diagram forming figure 6 (page 14) brings out this feature very strikingly. In 1898 Indian mica miners began to realize that their waste dumps contained a large supply of the material wanted for the manufacture of micanite, in which thin films of mica are cemented together and moulded into sheets, to serve many purposes for which the natural sheets only were used formerly. The waste heaps were consequently turned over, and the clear sheets of muscovite cleaned and split into thin films by gangs of children, who, by practice, could select the films of the required thickness with an accuracy which could scarcely be exceeded by the use of a micrometer. The large quantities of "flimsy" mica thus suddenly thrown on to the market raised the weight of mica exported, without a corresponding increase of value. Thus, figure 6 shows the curve for weight, suddenly rising in the years 1899—1901 until it crosses that for value, falling back with the reaction in the following year, but with a closer approximation of the two curves marking the years subsequent to 1901 when compared with those before 1898.

Export of films for micanite.

TABLE 34.—*Exports of Indian Mica during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	£
1897-98	11,608	71,234	6·14
1898-99	10,947	53,890	4·92
1899-00	22,599	73,372	3·25
1900-01	33,175	109,554	3·30
1901-02	16,298	70,034	4·30
1902-03	20,412	87,594	4·29
Average	*19,173*	*77,613*	*4·05*

The same lesson is expressed in table 34, from which it will be seen that the average value of the mica sent out of the country in 1897-98 was £6·14 per cwt., and that this value dropped down to £3·25 in

1899-1900, when the cheaper mica was exported in quantity, with only a partial recovery in the following years, during which both the cheap kinds and the more expensive sheets were exported together.

Source of mica raised for export.

Table 35 shows the relative contributions of the mica exporting provinces, and in the case of Bengal and Madras the only provinces in which the industry can be regarded as established, the mica exported was that produced within the Presidency in each case. It will be seen from this table that, during the years under review, the two chief producers contributed to the average total as follows:—

Bengal . . .	12,282 cwts., valued at .	.	£52,272
Madras . . .	6,872 „ „	.	£25,241

The average value of the mica sent out of Bengal was thus £4·26 per cwt., whilst that from Madras was £3·67.

TABLE 35.—*Exports of Mica for the years 1897-98 to 1902-03.*

YEAR.	BENGAL.			BOMBAY.			BURMA.			MADRAS.		
	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.
	Cwt.	£	£	Cwt.	£	£	Cwt.	£	£	Cwt.	£	£
1897-98	8,344	50,051	5·99	...	...	...	...		...	3,264	21.183	6·49
1898-99	7,720	31,954	4·14	11	50	4·55	10	258	25·8	3,206	21,628	6·75
1899-00 .	15,473	47,234	3·05	51	90	1·76	3	13	43·3	7,071	26,035	3·68
1900-01 .	13,633	63,049	4·62	25	100	4·00	...	...	...	19,517	46,405	2·38
1901-02 .	11,870	53,140	4·48	7	19	2·71	...	...	...	4,421	16,875	3·82
1902-03 .	16,651	68,202	4·10	6	72	12	...	...	...	3,755	19 320	5·15
Average	*12,282*	*52,272*	4·26	*20*	*66*	3·30	*3*	*54*	18·00	*6,872*	*25,241*	3·67

Distribution of mica exported.

Table 36 shows the average distribution of exported mica during the period under review. It will be noticed that the United Kingdom took the largest share, amounting to 73·2 per cent. of the average total value, but much of the mica sent to the United Kingdom is sold there for transmission to the Continent and America. The mica sent direct to America brought a higher price, as only the better qualities could face the heavy import duty imposed by the Dingley Tariff in 1897.

TABLE 36.—*Average Distribution of Indian Mica exported during the years 1897-98 to 1902-03.*

EXPORTED TO	AVERAGE QUANTITY.		AVERAGE VALUE.		Value per cwt.
	Cwts.	*Per cent. of total.*	£	*Per cent. of total.*	
United Kingdom .	14,843	77·4	56,799	73·2	3·83
United States . .	2,978	15·5	15,596	20·1	5·24
Germany . . .	1,027	5·4	3,920	5·0	3·82
Belgium . . .	141	0·7	634	0·8	4·50
France . . .	55	0·3	522	0·7	9·49
Hong Kong . .	90	0·5	26	...	0·29
Other Countries . .	39	0·2	116	0·2	2·97
Average Total .	19,173	100·0	77,613	100·0	4·05

Effects of the American tariff.

According to the Dingley Tariff, imported mica was divided into "unmanufactured" and "cut or trimmed," both being charged with a duty of 20 per cent. *ad valorem, plus* 6 cents a pound in the former case and 12 cents a pound in the case of "trimmed" mica. The duty had an immediate effect on the American mines by excluding all the lower grades of foreign mica, and thereby giving new life to many mines unable to face foreign competition without protection. For the five years preceding 1897 the average value of mica produced in the United States averaged £14,573 a year, whilst for the five years following 1897 the average annual value of the production was £25,518. The tariff was, however, insufficient to retard the growing demand for mica, and whilst the imports into the United States for the five years before 1897 had an average annual value of £33,481, those for the following five years averaged £61,880.

The tariff, however, naturally affected the Indian producer, who then contributed the chief part of the mica consumed in America, whilst the practice of preparing the mineral for the market became affected by the classification adopted, though some Indian producers were slow in observing the fact that mica sent to the London market in neatly trimmed rectangles was, on account of the higher duty, worth slightly less to the American buyer than the roughly dressed material.

Competition with Canada.

For many years India met with little competition from other countries in the American market, but during the last two years Canada has produced large quantities of phlogopite, and by meeting the requirements of the consumers of mica, has seriously challenged the supremacy of India. Table 37 shows approximately the relative positions of the three countries which, between them, produce well over 90 per cent. of the World's supply. India has so far enjoyed an easy lead, but there was a sudden expansion of the Canadian output in 1902, though reports recently received forecast a return to near the normal value of £32,000 for the year 1903.

TABLE 37.—*Value of Mica raised in the three principal producing countries.*

YEAR.	1898.	1899.	1900.	1901.	1902.	*Average.*
	£	£	£	£	£	£
India (*a*) . .	53,890	73,372	109,554	70,034	87,594	*78,888*
United States (*b*)	26,219	24,293	29,592	23,715	23,769	*25,518*
Canada . .	24,324	33,493	34,110	32,877	(*c*)82,192	*41,399*

(*a*) Exports only. | (*b*) Value at the place of production.
(*c*) Preliminary figures subject to revision.

Mining methods.

The methods of mining and the distribution of mines do not differ materially from those described in a special Memoir issued two years ago.[1] The short-sighted

[1] T. H. Holland: The Mica Deposits of India. Mem. Geol. Surv. Ind., vol. XXXIV, part 2, 1902.

policy then described is beginning now to impress itself on the mica-miners, who will be fortunate if no other country steps in to secure the market which could be controlled by India, or no artificial substance is found to meet the growing demand for mica, before the miners learn the necessity for reorganizing their methods.

Prospecting rules.

The rules for the grant of prospecting licenses and mining leases for mica in Bengal were revised in April 1902, and are printed *in extenso* with those for Madras in the Memoir on Indian Mica published by the Geological Survey in 1902. The important changes introduced in the rules were:—

(1) The levy of a royalty in the case of prospecting licenses at the rate of 5 per cent. on the sale value of mica;

(2) The abolition of the system of putting up leases of mica mines to auction, and provision for restricting operators to approved methods;

(3) The raising of the maximum period of leases to 30 years;

(4) The grant of power to lessees to relinquish their grants during the currency of their leases.

Prospecting licenses granted.

Of the prospecting licenses issued during the period under report, seven were granted in Nellore, four in Coimbatore, one in Godavari, and one in the Tinnevelly district, Madras Presidency. In the Central Provinces, one was granted in each of the three districts, Balaghat, Hoshangabad, and Chhindwara. In Burma, one license was issued for each of the two districts of Magwe and Mandalay, and two each for Myitkyina and the Ruby Mines district. In Assam, one license was granted in the Khasia and Jaintia hills. In Rajputana, four licenses were granted in Ajmer-Merwara, making a total of 27 licenses, covering 3,223 square miles.

Labour statistics.

Most of the mica mines having come under the control of the Indian Mines Act of 1901, labour statistics for the last three years of the period under review are now available. These are summarised in table 38, from which it will be seen that the mica industry comes next to gold in providing labour, whilst the risks attending mica-mining, as now practised, are rather greater than those of coal-mining in India, though the period is too short for a fair comparison of the two industries.

TABLE 38.—*Labour Statistics of Mica Mines for the years 1901 to 1903.*

	Province.	1901.	1902.	1903.	*Average for 3 years.*
Number of persons employed.	Bengal .	6,254	7,363	6,464	*6,694*
	Madras .	2,965	21,137	2,312	*2,471*
	TOTAL .	**9,219**	**28,500**	**8,776**	**9,165**
Number of Deaths from Accidents at Mica Mines.	Bengal .	2	2	9	*4·33*
	Madras .	16	...	...	*5·33*
	TOTAL .	**18**	**2**	**9**	**9·66**
Death-rate per 1,000 persons employed at Mica Mines.	Bengal .	0·32	0·27	1·39	*0·65*
	Madras .	5·39	...	...	*2·16*
	Average .	*1·95*	*0·21*	*1·02*	*1·05*

Petroleum.

Total production.

More progress has been made, during the period under review, in developing the petroleum resources than those of any other mineral. The output in 1897 amounted to 19 million gallons, and at the time was a record production, but the outturn has since been quadrupled, and in 1903 amounted, as shown in table 39, to nearly 88 million gallons.

Position of India amongst oil-producing countries.

But still India contributes little more than 1¼ per cent. of the World's supply of mineral oil.[1] Figures for all other countries are not yet obtainable for 1903, but table 40 (page 71) shows the position India occupied amongst oil-producing countries in 1901 and 1902, when its output exceeded 50 million gallons. With the United States and Russia overwhelming all others by producing over 90 per cent. of the World's supply, India takes a place amongst the second group of producers, and at the present rate of expansion will soon be competing with the Dutch East Indies, where the oil-fields are situated on a geological extension of the Assam-Burma belt.

[1] Preliminary returns for 1903 show that the Indian output was 1·29 per cent. of the World's total supply. (*Petroleum Review*, Oct. 22, 1904, p. 330.)

TABLE 39.—*Production of Petroleum during the years 1898 to 1903.*

YEAR.	QUANTITY.		Value.
	Gallons.	*Metric tons.* (*a*)	
			£
1898	22,234,438	89,295	76,821
1899	32,934,007	132,265	125,684
1900	37,729,211	151,523	148,755
1901	50,075,117	201,105	204,342
1902	56,607,688	227,340	217,816
1903	87,859,069	352,848	354,365

(*a*) The metric ton is assumed to be equivalent to 249 gallons of crude petroleum having a specific gravity of 0·885.

Imports.

India is, however, still far from meeting all its own requirements in mineral oil. The imports during the past six years have averaged nearly 85½ million gallons, valued at £2,314,801 (table 41, page 72), but the fall after the maximum of 1901-02 was continued into 1903-04, and it now appears, consequently, that foreign supplies are actually being displaced. It is interesting to notice that, of the two great producers, Russia and the United States, which have been supplying between them 93·5 per cent. of the imported foreign oil, Russia has been gradually increasing its predominance over the United States in the Indian market. In 1897-98 Russia contributed 58·1 per cent. of the imports and the United States 29·7 per cent., but in 1901-02 the former had secured 85·5 and the latter only 9·5 per cent. of the Indian custom, though a slight reversal occurred in 1902-03 (see table 41).

Value of imports.

As shown in table 42 (page 73), the predominance of Russia as a supplier of mineral oil to India is more a matter of quantity than of value, for although both countries supply large quantities of the cheaper kinds of oil, the supplies of more expensive kerosenes come from America, and the average price per gallon of the American oil is greater than that from Russia, prices on the whole having been enhanced in the former case from an average of 6·66 pence per gallon in 1897-98 to 7·81 pence per gallon in 1902-03, and having been depressed in the case of Russian oil from an average of 6·47 pence per gallon in 1897-98 to 5·93 pence in 1902-03.

TABLE 40.—*World's Production of Petroleum in 1901 and 1902.*

COUNTRIES.	1901. Gallons.	1901. *Per cent. of Total.*	1902. Gallons.	1902. *Per cent. of Total.*
United States . .	2,428,621,790	*41·84*	3,106,842,060	*47·94*
Russia . . .	2,980,899,460	*51·38*	2,818,901,575	*43·50*
Sumatra, Java and Borneo.	106,354,500	*1·84*	205,100,000	*3·17*
Galicia . . .	113,804,040	*1·96*	144,975,600	*2·24*
Roumania. .	49,215,600	*0·85*	72,097,550	*1·11*
India . . .	50,075,117	*0·86*	56,607,688	*0·87*
Japan . . .	38,500,000	*0·67*	41,755,000	*0·64*
Canada . . .	20,037,500	*0·35*	18,200,000	*0·28*
Germany. . .	10,977,050	*0·19*	12,378,625	*0·20*
Peru . . .	2,529,135	*0·04*	2,100,000	*0·03*
Italy . . .	353,500	*0·02* (Italy and Other Countries)	420,000	*0·02* (Italy and Other Countries)
Other Countries .	700,000		910,000	
TOTAL .	5,802,067,692	*100·00*	6,480,288,098	*100·00*

The petroleum resources of India are confined to the two systems of folded rocks at either end of the Himalayan arc—

Occurrences of Indian petroleum.

(1) The Iranian system on the west, including the Punjab and Baluchistan, and continued beyond British limits to Persia, where the oil-fields have attracted interest for many years.

(2) The Arakan system on the east, including Assam and Burma, with their southern geotectonic extension to the highly productive oil-fields of Sumatra, Java, and Borneo.

TABLE 41.—*Origin of Foreign Mineral Oil imported into India during the years 1897-98 to 1902-03.*

COUNTRIES.	1897-98.		1898-99.		1899-00.		1900-01.		1901-02.		1902-03.		*Average.*	
	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	*Gallons.*	*Per cent. of Total.*
Russia . .	50,672,226	58·1	50,940,879	62·2	57,658,254	76·9	67,350,856	83·4	84,514,016	85·5	71,197,917	80·1	63,722,358	74·6
United States .	25,967,322	29·7	23,602,079	28·8	15,043,622	20·1	9,798,257	12·1	9,437,107	9·5	13,425,470	15·1	16,212,310	18·9
Other Countries.	10,685,478	12·2	7,408,514	9·0	2,257,557	3·0	3,639,469	4·5	4,935,082	5·0	4,249,857	4·8	5,529,326	6·5
TOTAL .	87,325,026	100·0	81,951,472	100·0	74,959,433	100·0	80,788,582	100·0	98,886,205	100·0	88,873,244	100·0	85,463,994	100·0
Value .	£ 2,433,976		£ 2,163,152		£ 2,120,086		£ 2,304,562		£ 2,557,882		£ 2,309,151		£ 2,314,801	

TABLE 42.—*Average Annual Value of Mineral Oil imported during the years 1897-98 to 1902-03.*

COUNTRIES.	Average annual value.	Average value per gallon.
	£	Pence.
Russia	1,666,571	6·28
United States . . .	483,220	7·22
Other Countries . . .	165,011	7·17
Average Annual Total and Average Price.	**2,314,802**	**6·50**

In both areas the oil is associated with Tertiary strata, and has had probably similar conditions of origin in both cases, but the structural features of these areas are not equally suitable for the retention of oil in natural reservoirs. In Burma, however, the conditions have been locally ideal: the well-known Yenangyaung field lies in a N. N. W.—S. S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include a porous sand at depths of 200—300 feet, covered by impervious clay-beds, which have helped to retain the oil until the impervious layers are pierced by artificial wells. In the Baluchistan area the rock-folds have been truncated by agents of denudation, or have been dislocated by earth-movements, and much of the original stores of oil have disappeared. Oil-springs are common enough, but they are mere "shows," not connected with reservoirs which can be tapped by artificial means.

Punjab.

In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the Punjab is small, ranging between 1,000 and 2,000 gallons a year. During the past six years the recorded production has been as follows:—

1898	1,510 gallons.
1899	1,104 "
1900	1,874 "
1901	1,812 "
1902	1,949 "
1903	1,793 "

Baluchistan.

Unsuccessful attempts have been made to develop the oil resources indicated by springs in different parts of Baluchistan; the most prominent of these are near Khatan in the Mari hills and Moghal Kot in the Sherani country, where small oil springs which were examined in 1891 were found to yield oil of a very high quality. The oil-spring in the neighbourhood of Moghal Kot affords a good illustration of the way in which a country, originally well endowed with the necessary conditions for the natural production of petroleum, may lose its resources by subsequent destruction of the natural reservoirs. The Moghal Kot oil-bearing beds form a very open anticlinal fold, whose axis pitches to the E.N.E., and if the dome possessed the necessary plastic, impervious envelope, the oil rising up from below would have become concentrated in the porous beds which form the saddle, but for the fact that along this line the rocks are more easily eroded by surface water, and the anticline thus forms the gorge of a river by which the rocks have been opened to permit the waste of oil for an indefinite time. This is, unfortunately, the history of most of Baluchistan and the Punjab, where the oil-bearing strata are either disturbed beyond the plastic limit of the impervious layers, or the whole series of beds (those which are porous and hold the oil, as well as those which are impervious and limit its movements underground) have been exposed to the air. In this respect the Punjab-Baluchistan area offers fewer prospects of success than the eastern group of Assam and Burma, where, especially in the latter area, the rocks are less disturbed and the softer shales have retained their nearly impervious character.

Up to the present, however, all attempts to develop the oil prospects of India have been without success, except in Burma and North-East Assam. Burma holds an easy lead, and if its resources hold out, the present rate of development will soon displace foreign supplies.

Assam.

The delay in the development of the promising petroleum resources of Assam is an instance of a remarkable diffidence and want of enterprise existing in a commercial community which could show the reckless speculation of the gold boom of 1890. As long ago as 1865 an account of the Makum area was published by Mr. H. B. Medlicott, F.R.S., in the Memoirs of the Geological Survey, and trial borings were then recommended. This advice was followed in 1867, when a Calcutta firm obtained permission to prospect, and struck a promising oil-spring at a depth of 118 feet near Makum; but nothing more was done until 1883, and only very slow development occurred in the following sixteen years. The Assam Oil Company was, however, formed in April 1899 with a nominal capital of £310,000, most of which was quickly called up and invested in the erection of a new refinery at Digboi and in systematic drilling operations, with the result that the output rose from 631,571 gallons in 1901 to 2,528,785 gallons in 1903. Besides the ordinary illuminating oil and solid paraffins, the Assam Oil Company has made a successful attempt to put petrol on the Indian market. The following table shows how the output in this area has been rising during the last six years:—

1898	547,965 gallons.
1899	623,372 „
1900	753,049 „
1901	631,571 „
1902	1,756,759 „
1903	2,528,785 „

The belt of Tertiary rocks extending from the north-eastern corner of Assam for some 180 miles south and west shows frequent signs of oil, nearly always in association with coal and sometimes associated with brine-springs and gas-jets. The series of earth-folds in which this corner of Assam occurs stretches southwards to Cachar, where oil springs are also known, through the little-known Lushai hills into Arakan, and in the same system of parallel folds occur the oil-fields of the Arakan coast on one side of the Yoma and those of the Irawadi valley on the other (see plate 6).

Burma.

The most productive oil-fields of Burma are those on the eastern side of the Arakan Yoma, in the Irawadi valley, forming a belt stretching from the Magwe district, in which the well-known field of Yenangyaung occurs, through Myingyan, in which Singu occurs, across the Irawadi into Pakokku, where Yenangyat is situated. Oil is, however, known further south in Minbu, Thayetmyo and Prome, and further north in the Chindwin valley, but these areas have not so far been thoroughly prospected, and the great development which has recently taken place has been the direct outcome of work in the three fields, Yenangyaung, Yenangyat, and Singu.

Yenangyaung.

Yenangyaung, the best known and most developed of the fields, still holds the lead as a producer. The oil in this area has been worked by native wells on both sides of the dome for well over 100 years, and before 1886 the annual yield was generally over two million gallons, but soon after systematic drilling was introduced in the central Kodaung tract in 1887 the output gradually rose to over 10 million gallons in 1894, and last year, 1903, reached a record of 56,920,662 gallons.

TABLE 43.—*Production of the Burma Oil-fields between 1898 and 1903.*

YEAR.	Yenang-yaung, Magwe District.	Singu, Myingyan District.	Yenangyat, Pakokku District.	Akyab.	Kyauk-phyu.	TOTALS.	
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	*Metric tons.*
1898 . .	15,484,301	...	6,036,088	58,025	105,549	21,684,963	*187,088*
1899 . .	22,111,514	...	10,030,790	50,559	116,668	32,309,531	*129,757*
1900 . .	27,123,325	...	9,701,769	36,852	112,342	36,974,288	*148,491*
1901 . .	37,482,935	...	11,843,341	22,355	93,103	49,441,734	*198,561*
1902 . .	40,712,142	174,880	13,824,390	36,794	100,774	54,848,980	*220,277*
1903 . .	56,920,662	5,617,381	22,665,518	52,968	71,962	85,328,491	*342,685*
Average .	*33,305,813*	*2,896,130* (*a*)	*12,350,316*	*42,926*	*100,233*	46,764,665	*187,810*

(*a*) Two years only.

Yenangyat.

Yenangyat yielded very small supplies of petroleum before 1891, when drilling was started by the Burma Oil Company. The expansion was slow until 1894, when 324,086 gallons were produced, but rose rapidly to 6,036,088 gallons in 1898 and to 22,665,518 gallons in 1903. The oil from the Yenangyat area, and that from its southward extension on the other side of the Irawadi river near Singu, contains a higher proportion of the lighter hydrocarbons than the Yenangyaung crude oil.

Singu.

Singu has suddenly come into prominence. Petroleum was first struck by the Burma Oil Company in this area on the 30th October 1901, and arrangements were then made to provide tanks for its reception. Production did not consequently begin till 1902, when only 174,880 gallons were turned out with the opening of the new wells, but the output jumped up to 5,617,381 gallons in 1903. The crude oil first obtained had a specific gravity of 0·8247 and flash point under 40° F., in consequence of which primary stills were erected on the field to remove the light naphthas before transport to the Rangoon refineries.

Arakan coast.

Besides the Upper Burma oil-fields, the islands off the Arakan coast, noted for their mud volcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Barongo Island near Akyab and on Ramri Island in the Kyaukphyu district. During the past six years the average output of the former area has been 42,926 gallons, whilst in Kyaukphyu the output in the same period has averaged about 100,000 gallons, with a distinct tendency to decline.

Bulk system of transport.

The main factor which has contributed elsewhere to the recent great advances in oil production, namely, the general adoption of the bulk system of transport and distribution, has been receiving the attention of those interested in the development of the Burma oil-fields. The Burma Oil Company have laid a pipe-line from Yenangyat, through Singu, to the Yenangyaung area, and are now preparing to connect all the fields in a similar way with their refineries in Rangoon, a distance of 275 miles; they are adding several large tank steamers to their present fleet of five, with storage tanks at the principal Indian ports. The enterprise shown in the laying out of capital in Burma evidently anticipates an expansion in the trade well beyond the record output of 1903, and the fact that mineral oil is being rapidly adopted as fuel instead of coal, removes the fear of over-production which seemed likely as long as petroleum was used only as an illuminant.

Ruby.

During the period under review the ruby-mining industry in Upper Burma underwent a new and favourable phase, the mineral having become, next to petroleum, the most profitable source of revenue amongst Burmese minerals. Various leases were granted in the ruby-bearing area near Nanyaseik in the Myitkyina district, and in the "stone-tract" of the Sagyin hills, in Mandalay district, and the results have been mostly profitless; but the returns for the Mogok area, where the Burma

Ruby Mines Company is paramount, show that the industry has entered a most encouraging phase. The Company was granted the right in 1889 to mine for rubies and to levy royalties from persons working by native methods, the lease being renewed in 1896 for 14 years, at a rent of Rs. 3,15,000 a year *plus* a share of the profits. The results being, however, unsatisfactory from the shareholders' point of view, the rent was reduced in 1898 to Rs. 2,00,000, the share of the profits being, at the same time, raised from 20 to 30 per cent. A dividend of 5 per cent. was paid for the first time in 1898, when the value of the rubies obtained amounted to £57,950. In 1899 the Company obtained rubies to the value of £90,848 and paid a dividend of 12½ per cent.: in this year three unusually valuable stones were found, one of 77 carats being valued at 4 lakhs of rupees (£26,666). In the following year, 1900, the value of the stones raised increased to £97,326, and the Company paid a dividend of 17½ per cent. The year 1901 showed the record output of stones valued at £104,476, whilst in 1902 they brought £86,895. In the last year, 1903, the Company's receipts were £98,575, and profits on the year's working £44,950.

Salt.

Origin of Indian salt.

There are three kinds of sources from which salt is produced in India:—

(1) Sea-water, from which 61·8 per cent. of the total production was obtained during the period under review;

(2) Sub-soil water and lakes in areas of internal drainage, in both of which the origin and mode of concentration of the salt are the results of essentially similar natural processes. From these sources about 27 per cent. of the total was obtained; and

(3) Rock-salt beds, from which 11·2 per cent. of the total was obtained by mining and quarrying.

Production.

During the past six years, 1898 to 1903, the average annual production of salt in India amounted to 979,572 statute tons. Table 44 shows the variations for the past six years, and plate 4 shows graphically the position India has taken amongst the large salt-producing countries during the past 22 years.

TABLE 44.—*Production of Salt in India (excluding Aden).*

YEAR.	Statute Tons.	*Metric Tons.*
1898	986,158	*1,001,082*
1899	920,659	*935,432*
1900	1,005,185	*1,021,315*
1901	1,102,039	*1,119,672*
1902	1,040,206	*1,056,899*
1903	823,184	*836,304*
Average	*979,572*	*995,282*

TABLE 45.—*Provincial Production of Salt during the years 1898 to 1903.*

	1898.	1899.	1900.	1901.	1902.	1903.	*Averages.*
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Statute Tons.*
Aden . . .	41,217	41,181	49,763	87,800	58,953	71,656	*54,428*
Bengal . . .	...	...	174	112	44	94	(*a*) *106*
Bombay . .	343,569	368,072	460,262	323,909	381,611	267,619	*357,507*
Burma . . .	18,223	23,240	20,835	21,500	20,013	26,174	*21,664*
Gwalior State .	456	333	352	491	485	489	*434*
Madras . . .	251,875	268,962	322,244	339,544	358,450	244,923	*297,666*
Northern India .	359,790	248,574	190,532	405,068	269,177	270,068	*290,535*
Sind . . .	12,245	11,478	10,786	11,415	10,426	13,817	*11,695*
TOTAL Statute Tons .	**1,027,375**	**961,840**	**1,054,948**	**1,189,839**	**1,099,159**	**894,840**	**1,038,000**
Metric Tons . .	*1,043,862*	*977,260*	*1,071,877*	*1,208,933*	*1,116,797*	*900,200*	*1,054,665*

(*a*) Average of 4 years.

Of the provinces contributing to this amount, Bombay, with an average annual production of 357,507 tons, and Madras, with an average of 297,666 tons, between them contributed almost exactly two-thirds of the total. Of the salt produced in Bombay, about 78 per cent. was obtained from sea-water, the rest being manufactured from sub-soil brine at Kharaghora and Udu on the border of the lesser Rann of Cutch, and possibly derived from infiltrated sea-water. The Madras salt is practically all made from sea water, a very small quantity of spontaneous salt being collected at Pandraka in the Masulipatam sub-division.

Provincial contributions to the total production.

The chief manufacture of salt in Burma takes place also along the sea-coast, but sub-soil brine is evaporated at various places in Upper Burma, notably in the Lower Chindwin, Sagaing, Shwebo, Myingyan, and Yamethin districts, and in smaller quantities in Minbu and Meiktila, as well as at Mawhkeo in the Hsipaw State. During the past six years the average annual production of this salt in Burma has been 3,432 tons.

In Sind 88 per cent. of the salt raised during the years 1898 to 1903 was obtained from sea-water, and 12 per cent. from the Saran and Dilyar deposits on the edge of the great desert.

From the point of view of the geologist and mineralogist, the last two groups of occurrences, namely, sub-soil salt and rock-salt, are naturally of more interest than the first, though from the financial point of view the salt from sea-water, being the predominating fraction, is the most important source of revenue.

Sub-soil and internal lake brine.

The second form of occurrence is characteristic of areas in which evaporation of rain-water is excessive compared to run-off, and the salt recovered in these areas is that merely arrested on its journey to the sea, where, in the same way, it is concentrated by evaporation of the water. The most prominent of such areas is the desert-belt of Rajputana including the salt-lakes of Sambhar, Didwana, Falodi, Lonkara-sur and Kachor-Rewassa, with a brine-impregnated sub-soil along the whole valley of the Luni, as well as the country to the west in Sind, around the Rann of Cutch and the delta of the Indus. To the north of the Rajputana country sub-soil brine is raised and evaporated for salt in a cluster of villages in the Sultanpur mahal, south-west of Delhi. Other places occur in parts of the United Provinces and in Berar, where large quantities of salt were formerly obtained from sub-soil brine in the alluvium of the Purna River. In Gwalior State salt is regularly manufactured from sub-soil brine, the average annual production during the years 1898 to 1903 having been 434 tons. In Behar a small quantity of salt is separated in the manufacture of saltpetre. The returns for the past four years for Bengal, with an average of 106 tons per annum, quoted in table 45, refer to salt made in this way.

Sambhar Lake.

The most important source of salt of this group is the Sambhar Lake in Rajputana. Recent investigations have shown that Sambhar is a silt-filled depression in the Aravalli schists and gneisses, in which a body of mud and sand, with kankar and gypsum (some 75 feet thick in what appears to be about the centre of the depression) includes from 2 to 12 per cent. of sodic chloride, with smaller quantities of sodic sulphate, sodic carbonate, and potassic sulphate. Every year the water brought in by the rivers, which are in flood during the monsoon, forms a lake some 60 square miles in area and 2 to 3 feet deep. The water, which is fresh when it first comes in, takes up salt from the accumulated stocks in the silt and forms a strong brine, which is partly led into prepared enclosures (*kyars*) for the separation of salt by solar evaporation, partly isolated by temporary reservoirs constructed to cut off bodies of the lake-water in anticipation of the recession towards the centre during evaporation, and partly forms a thin crust of white glistening salt on the bed of the lake, where it is allowed to remain until the arrival of the next monsoon and the usual annual flooding of the lake.

Production and prospects of Sambhar.

During the past six years the average annual removal of salt from the Sambhar brine has been 135,051 tons, which is 13·8 per cent. of the average annual production for India during the same period. Since the lake came under the direct control of Government in 1871 the salt removed has amounted to about 4 million tons. During the past few years the quality of Sambhar salt is said to have depreciated, and it has been suspected that the large quantities which have been removed have at last made an impression on the great stores of salt which must have accumulated in the lake silt, appreciably raising the proportion of the associated compounds, sodium sulphate, sodium carbonate, and potassium sulphate. An investigation is now being made with a view to forming an estimate of the total and relative amounts of these salts present in the lake mud, and of obtaining a forecast of the effects of fractional solution and crystallization under the existing system of manufacture.

Distribution of Sambhar salt.

The chief fraction of the output of Sambhar is consumed in the United Provinces, but small quantities reach as far even as Behar against the competition of foreign salt imported through Calcutta. The following table shows the average annual distribution of Sambhar salt during the years 1897-98 to 1902-03:—

United Provinces	91,443 tons, or	68·3
Rajputana	20,371 " "	15·3
Central India	11,713 " "	8·8
Punjab and North-West Frontier Province	9,109 " "	6·8
Central Provinces	716 " "	0·5
Behar	175 " "	0·1
Sind (in 1902-03 only)	294 " "	0·2

Distribution of Didwana and Pachbadra salt.

The salt being manufactured at Didwana is practically all consumed in Rajputana and the adjoining districts of the Punjab. During the years 1897-98 to 1902-03 the average annual amount, 10,502 tons, disposed of from this source was divided into 8,123 tons for the Punjab and 2,379 tons for Rajputana. Pachbadra salt, of which only small lots entered the Punjab, had an average distribution as follows during the period under review:—

Average Distribution of Pachbadra Salt during the years 1897-98 to 1902-03.

United Provinces	15,346 tons, or	45·6 per cent. of average total
Rajputana	9,216 " "	27·3 " " "
Central India	5,553 " "	16·5 " " "
Central Provinces	3,562 " "	10·6 " " "
TOTAL	33,677 tons.	

Production of rock-salt.

The production of rock-salt in the Punjab, North-West Frontier Province and Mandi State is shown in table 46, from which it will be seen that, of the average annual output of 109,540 tons, 89,023 tons, or 81·2 per cent., came from the Salt Range mines, whilst 14·5 and 4·3 per cent. respectively came from Kohat and Mandi.

TABLE 46.—*Production of Rock-Salt during the years 1898 to 1903.*

YEAR.	Salt Range, Punjab.	Kohat North-West Frontier.	Mandi State.	TOTAL.	Percentage of total salt production of India.
	Tons.	Tons.	Tons.	Tons.	
1898	91,117	17,223	4,754	113,094	11·4
1899	91,488	17,693	4,621	113,802	12·3
1900	81,534	14,900	4,122	100,556	10·0
1901	91,816	14,965	4,845	111,626	10·1
1902	87,426	14,674	5,152	107,252	10·3
1903	90,736	15,598	4,554	110,888	13·5
Average . . .	*89,023*	*15,842*	*4,675*	109,540	*11·2*
Per cent. of Average Total .	81·2	14·5	4·3	100·0	

The Salt Range deposits.

The chief deposits of rock-salt are in the so-called Salt Range of the Punjab, where the seams of salt and included marl partings have, where worked in the Mayo mines at Khewra, an aggregate thickness of 550 feet, of which five seams of pure salt make up 275 feet, the rest, known as *kalar*, being too earthy and impure to be marketable. These beds occur in a formation lying directly underneath beds of Lower Cambrian age, but it is suspected that they may be of Lower Tertiary age, like the other salt deposits of this part of India, and that they have arrived in their present apparently anomalous position by an overthrust of the older fossiliferous beds.

Mining for rock-salt is carried on in the Mayo mines, Jhelum district, the Warcha mines in the Shahpur district, and across the Indus at Kalabagh. The rock-salt in this area varies from white to brick-red in colour and thus differs in colour from that of the Kohat area.

The Mayo mines.

The most important of the mines in the Salt Range are the Mayo mines near Khewra (32° 39′; 73° 3′). In this area salt-quarrying was practised for an unknown period before the time of Akbar, and was continued in a primitive fashion until it came under the control of the British Government with the occupation of the Punjab in 1849. In 1872 the system of mining was reorganized, and the work now in operation was planned out by Dr. H Warth, late Deputy Superintendent, Geological Survey of India.[1]

The rock-salt being raised in the Mayo mines has, on account of its purity, a wide distribution. A recent analysis of one of the seams gave the following results:—

Sodium chloride	98·86
Sodium sulphate	0·57
Sodium carbonate	trace
Magnesium chloride	nil
Moisture	0·08
	99·51

The Warcha mine.

In the Warcha mine, Shahpur district, the seam of rock-salt being worked is 20 feet thick, with a one-foot parting of marl, dipping 30° to the N. N. W.

Kalabagh quarries.

About two miles E.N.E. of Kalabagh on the Indus, rock-salt is worked in open quarries on the east slope of Sandagar hill.

Distribution of Salt Range salt.

The rock-salt raised in the *cis*-Indus mines and Kalabagh quarries is principally consumed in the Punjab and North-West Frontier Province. During the past six years the average annual sales in these provinces amounted to 70,964 tons, or 82·3 per cent. of the total. In the same period the rock-salt sent to the United Provinces averaged 10,049 tons a year, or 11·3 per cent., whilst as much as 5·7 per cent. of the total sales, or an annual average of 4,933 tons, reached as far as Behar, and small consignments of about 10 tons a year were despatched to Lower Bengal. The average annual amount of 580 tons which entered Sind formed 0·7 per cent. of the sales for the years 1897-98 to 1902-03.

Kohat quarries.

The Kohat salt is grey in colour with transparent patches. It is worked in open quarries, and the masses exposed may be regarded as practically inexhaustible at the present rate of output. In the anticlinal at Bahadur Khel, where the salt is seen to be at the base of Tertiary system, the beds can be

[1] For detailed description, see "Report on the Inspection of the Mayo Salt Mine," by J. Grundy, 1898, pp. 13-15.

traced for a distance of about eight miles, with an exposed thickness of over 1,000 feet.

Mandi quarries.

In Mandi State, rock-salt is worked in open quarries near the faulted junction of the Tertiary and the older unfossiliferous rocks at Guma and Drang. The Mandi salt is of a dirty plum-colour, containing earthy impurities which bring down the available sodic chloride to 60 or 70 per cent.

Imports and origin of Foreign salt.

With low freight-rates from Europe, large quantities of salt are imported, especially into Bengal and Burma, against the competition of the domestic produce. The salt imported during the six years under review averaged 433,754 tons per annum, of which 56·1 per cent., as shown by table 47, came from the United Kingdom, the remaining supplies being obtained, in order of average quantity, from Germany, Aden, Arabia, Egypt, and Persia. The average annual value of the salt imported during the six years was £456,263.

TABLE 47.—*Origin of the Salt imported during the years 1897-98 to 1902-03.*

Imported from	Average annual quantity imported.	Per cent. of total.
	Tons.	
United Kingdom	243,216	56·1
Germany	56,928	13·1
Aden	49,350	11·4
Arabia	42,887	9·9
Egypt	28,377	6·5
Persia	12,441	2·9
Other Countries	555	0·1
Average Total for the years 1897-98—1902-03	433,754	100·0

The amounts taken by the different provinces maintained a fairly constant ratio throughout the period, with the following yearly averages:—

Imported to Bengal	389,376	tons.
" " Burma	43,978	"
" " Bombay	260	"
" " Madras	91	"
" " Sind	49	"
TOTAL	433,754	"

Of the average annual amount imported, therefore, 89·8 per cent. entered India through Bengal. The distribution of foreign salt in India in competition with the chief sources of production is reviewed in the annual reports of the various Salt Departments.

Trans-Frontier Imports and Exports.

Small quantities of salt are also imported across the land frontier, coming in with borax mainly from Tibet. During the years 1898 to 1903 these imports averaged 1,476 tons annually, of which 1,416 tons came from Tibet. At the same time considerable quantities of Indian salt were sent across the frontier. The average annual export in this way during the six years under review amounted to 41,170 tons. The principal fractions went to Nepal (12,943 tons) and into Kashmir (11,234 tons).

Saltpetre.

Conditions essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of Winogradsky's so-called nitroso and nitro bacteria, converting urea and ammonia successively into nitrous and nitric acids, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Behar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., confined to an annual range of 68°, and for a large part of the year, when the air has a humidity of over 80 per cent., with a diurnal range not exceeding 8° above or below 84° F., the conditions are unusually favourable for the growth of the so-called "nitrifying" bacteria.

With a population largely using wood and cow-dung for fuel, the soil around villages naturally would be well stocked with potash; and finally, with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these conditions Behar has for many years yielded some 20,000 tons of saltpetre a year.

System of manufacture.

The system of manufacture has been very frequently described in detail,[1] and consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallization. The impure sodium chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

Production and export.

The returns for production are so manifestly imperfect, being considerably below the amounts of export, that the export figures must be taken as the only index, though still an imperfect one, to the extent of the manufacture. The export figures for the past six years are given in table 48, showing an average annual export of 382,353 cwts., valued at £262,592.

Variations in exports.

There is no definite directional change indicated by these figures, but a comparison with the returns for the past 20 years shows that there has been only a slight reduction in the amount of exported saltpetre, in spite of the discovery elsewhere of large deposits of sodic nitrate, now being largely consumed in America, of variations in tariff, and of wholesale changes in the substances used for manures and for the manufacture of explosives. For the six years 1878—1883 the average quantity of saltpetre exported amounted to 405,568 cwts. a year, whilst for a similar period ten years later, namely, 1888 to 1893, the average annual exports were 389,989 cwts. The highest values, ranging from about £600,000 to nearly £900,000 a year, occurred at the time of the American Civil War from 1860 to 1864, but saltpetre was then an essential constituent of explosives and India had almost a monopoly of supplies.

[1] G. Watt, Dictionary of the Economic Products of India, vol. VI, part II, s. 686, p. 433, and literature quoted.

TABLE 48.—*Total Exports of Saltpetre during the years 1897-98 to 1902-03.(a)*

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1897-98	417,788	*21,224*	265,831	12·73
1898-99	365,256	*18,555*	232,896	12·75
1899-00	397,402	*20,189*	256,210	15·16
1900-01	348,636	*17,711*	294,249	16·88
1901-02	354,412	*18,005*	237,880	13·42
1902-03	410,626	*20,861*	288,487	14·05
Average .	*382,353*	*19,424*	*262,592*	*13·73*

(*a*) Includes exports across the frontier which averaged 380 cwts., due mainly to 2,233 cwts. sent into Kashmir in 1900. The saltpetre sent across the frontier seldom exceeds a ton per annum.

Distribution of exported saltpetre.

There have been various changes amongst the consumers of small quantities, amounting altogether to about 20 per cent. of the total, but the quantities sent annually to the three larger markets, United Kingdom, United States, and Hong Kong, amounting to 80 per cent. of the total, have remained fairly constant.

Provincial shares in the exports.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports through Calcutta, during the period under review, having amounted to 98·5 per cent. of the total. Of the remaining small amount exported, 1·2 per cent. left *viâ* Karachi. The average annual exports from the different provinces have been as follows during the years 1897-98 to 1902-03:—

Bengal	376,254	cwts.
Bombay	930	"
Madras	61	"
Sind	4,728	"
TOTAL .	381,973	"

The Calcutta supply is obtained mainly from Behar, as shown in table 50, which has been compiled from returns published each year by the Commissioner of Northern India Salt Revenue.

TABLE 49.—*Average Distribution of Saltpetre exported by Sea during the years 1897-98 to 1902-03.*

EXPORTED TO	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
United Kingdom	117,126	30·7
Hong Kong	98,320	25·7
United States	91,790	24·0
Mauritius	24,070	6·3
France	22,752	6·0
Straits Settlements	10,012	2·6
Ceylon	7,569	2·0
Japan	5,227	1·4
Other Countries	5,107	1·3
Average Total for the years 1897-98—1902-03	381,973	100·0

TABLE 50.—*Average Annual Imports of Saltpetre into Calcutta for the years 1897-98 to 1902-03.*

OBTAINED FROM	Average annual quantity.	*Per cent. of average total*
	Cwts.	
Behar	230,120	59·1
United Provinces	113,680	29·2
Punjab	44,300	11·3
Rajputana and Central India	1,540	·4
Lower Bengal	100	...
Average Total	389,740	

Trans-Frontier imports.

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the past six years the imports from Nepal have averaged 9,417 cwts. with considerable yearly variations, as shown below:—

Saltpetre imported from Nepal.

1897-98	9,308 cwts.
1898-99	12,836 ,,
1899-00	15,655 ,,
1900-01	4,590 ,,
1901-02	11,352 ,,
1902-03	2,758 ,,
Annual Average	*9,417* ,,

As the total annual imports of saltpetre averaged only 9,430 cwts. during the six years under review, the contribution from Nepal was the only one of importance. The annual values returned for the total imports give an average of £5,816, or of 12·34 shillings per cwt.

Tin.

Unworked occurrences.

Tin has a wider distribution than is generally recognised, and its minerals are often overlooked through the difficulty in distinguishing them from other heavy minerals. Isolated crystals of cassiterite have been found recently in pegmatites associated with gadolinite in the Palanpur State,[1] whilst in the Hazaribagh district of Chota Nagpur instances have been recorded of the accidental production of tin from river sands by the native iron smelters, in addition to the recorded occurrences of ores *in situ*. The principal deposit, which has either been wrongly described or has received less attention than it deserves, occurs in the Palganj estate near the Barakar river.

Worked deposits.

The only persistent attempts made to work tin have been in Burma, where cassiterite is obtained by washing river gravels in the Bawlake State, Karenni, Southern Shan States, and in the Tavoy and Mergui districts of South Burma. The work done on these deposits hitherto has been, however, on a

[1] Rec. Geol. Surv. Ind., xxxi, 1904, 43.

smaller scale than might be expected from the favourable reports which have been made as to their extent and richness. Table 51 shows the amounts of tin-ore raised during the years under review in Tavoy and Mergui, but the returns are probably approximate only, and no returns are available for Upper Burma. The average for the period has been 1,645 cwts. (82·5 tons) valued at £6,876.

TABLE 51.—*Production of Tin-ore in South Burma.*

YEAR.	Tavoy.	Mergui.	TOTAL. Quantity.	TOTAL. Value.
	Cwts	Cwts.	Cwts.	£
1898 .	...	780	780	2,553
1899 .	14	1,408	1,422	7,900
1900 .	19	2,059	2,078	8,534
1901 .	22½	1,372	1,395	7,773
1902 .	25	1,970	1,995	5,340
1903 .	34	2,164	2,198	9,153
Average	*19*	*1,626*	*1,645*	*6,876*

Exports of block tin. The metal is exported mainly in the form of block tin, almost all of it going to the Straits Settlements. This, during the years 1897-98 to 1902-03, averaged 661 cwts. a year, as shown in table 52.

Imports of block tin. The tin exported from Burma is a small quantity compared to the requirements of the country. Table 53 shows the amounts of foreign unwrought block tin which have been consumed in India during the period under review, and in addition to these quantities, smaller quantities of tin-plates are imported. By far the largest quantity of block tin imported into India comes from the Straits Settlements. Out of the average total of 26,867 cwts., the quantity coming from the Straits averaged 25,407 cwts. per annum. A curious feature connected with the imports is the fact that the quantities of foreign tin imported have not increased since statistics of weight were first recorded in 1875-76. In that year the tin imported was reported to amount to 36,159 cwts., of which 31,479 cwts. came from the Straits.

TABLE 52.—*Exports of Burmese Block Tin for the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.
	Cwts.	£
1897-98	906	2,816
1898-99	810	2,898
1899-00	757	4,613
1900-01	534	3,08
1901-02	455	2,574
1902-03	502	2,881
Average	*661*	*3,144*

TABLE 53.—*Consumption of Foreign Block Tin in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1897-98	38,483	146,554	1,609	36,874
1898-99	29,099	110,667	1,396	27,703
1899-00	17,292	91,525	2,473	14,819
1900-01	22,591	146,135	2,624	19,967
1901-02	25,907	156,212	1,853	24,054
1902-03	27,830	169,731	1,495	26,335
Average	*26,867*	*136,804*	*1,908*	*24,959*

As regards the prospects of tin-mining in Burma, it may be worth notice that the country in which the ore occurs lies in a belt connecting Yunnan, the south-west province of China, in which tin-mining is said to support a large population,[1] and the well known tin-ore deposits of the Straits Settlements to the south, from which, in 1903, 54 per cent. of the World's supply of tin was obtained.

Prospects of tin-mining.

At the same time, it should be kept in mind that the tin-ore of the Straits has been obtained entirely from alluvial deposits, and that the ore found in lodes has always turned out to be too poor to work. The rapid rate of rock denudation in the wet zone of the tropics is responsible for the fact that rich alluvial deposits may accompany poor lodes, and consequently the occurrence of tin-ore in the sands and gravels of Burma does not warrant the hope that workable lodes will be found before the placer deposits are exhausted. That rich placer deposits exist of sufficient magnitude in Burma also does not necessarily follow from the fact that there is a continuity in the solid geology; the existence of a placer deposit is but a temporary accident in the geological history of a country, and each one must be gauged for itself.

[1] A. Leclère. Exploration géologique des Provinces chinoises voisines du Tonkin. *C. R., 29eme Session, Assoc. Fr.*, 1900, ii, 916-926. Abs. *Trans. Inst. Mining Engineers*, XXII, 1901-02, 715.

IV.—MINERALS OF GROUP II.

Alum and Aluminium-ore.

THE separation of the sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of nitre or wood-ashes, was formerly an important industry in a few places, and, on a smaller scale, was practised at numerous places in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending network of railways, have now nearly killed the native industry. Table 54 shows that during the past six years the consumption of foreign alum in India has averaged 66,086 cwts.

TABLE 54.—*Consumption of Foreign Alum in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption of foreign alum.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1897-98	103,307	30,528	3,050	**100,257**
1898-99	70,999	18,837	3,320	**67,679**
1899-00	65,953	17,404	4,037	**61,916**
1900-01	64,528	18,398	3,137	**61,391**
1901-02	49,914	15,137	2,240	**47,674**
1902-03	61,081	18,789	3,478	**57,603**
Average	*69,296*	*19,915*	*3,210*	**66,086**

No returns are available to show the amount of production in India. Near Kalabagh, on the Indus, considerable quantities of a pyritous shale are extracted for this purpose, but the mining is carried on in an irregular, fitful way, and the returns are probably mere rough estimates. In 1898 the output was reported to amount to 750 tons, valued at £3,150, but no returns are available for 1899 and 1903. In 1901 and 1902 the production was reported to be 98 and 112½ tons respectively.

Bauxite. India possesses a possible asset of great value in the deposits of laterite which cover considerable areas in the Peninsula and Burma. On account of their commonly rusty colour, and on account of the fact that locally the native smelters, content with a poor ore, have employed laterite as a source of iron, the only chemical work done on laterite was formerly devoted to a determination of its content in iron. It has only recently been ascertained that many of the deposits contain large quantities of alumina, and are in all essential respects identical with the substance known as bauxite, which is now the chief source of aluminium. It is a curious coincidence that for a long time the original bauxite of Les Baux was, like laterite, first worked without success as a source of iron.

It is difficult at present to fully estimate the value of this discovery, as a deposit of laterite, which would ordinarily be regarded as small and of little consequence, contains enough alumina in some of the instances examined to completely swamp the market of bauxite, of which the World's total production is at present little more than 110,000 tons a year. Without any disturbance of present prices, the aluminous laterites would hardly pay, at the ordinary rate for first class bauxites of 21 to 22 shillings a ton, to mine for export to Europe and America, and they must consequently be utilized for the extraction of alumina on the spot, either for export as such, or for the manufacture of aluminium in the country. To prepare the alumina from the bauxite (or laterite) would, according to the most recent processes, require the use of caustic soda, which is not at present made in the country. But one of the latest successful processes for the manufacture of caustic soda involves the separation of chlorine (from which bleaching powder is prepared) by the electrolytic decomposition of dilute brine, and as both caustic soda and bleaching powder are now largely imported for use in paper-making, there would be a market for both, apart from the requirements of alumina manufacture.

Amber.

The returns for amber show the irregularities which might be expected of an industry conducted in a casual fashion by the half-civilized inhabitants of an unadministered area. The following table (table 55) shows the estimated production for the six years under review :—

TABLE 55.—*Production of Amber in the Myitkyina District, Upper Burma.*

YEAR.	Quantity.	Value.
	Cwts.	£
1898	114	1,061
1899	20	151
1900	9	103
1901	97	(*a*) 11
1902	30	432
1903	37	414
Average .	*51*	*362*

(*a*) Poor qualities only raised for medicine in 1901.

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills near Lalaung village at about lat. 26° 10′ and long. 96°. The substance is found in clays of probably miocene age, and fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example, at Mantha in the Shwebo district, and on the oil-field of Yenangyat in the Pakokku district. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders) and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties, and the name burmite has been consequently suggested for it as a specific distinction.[1] The well known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid, and

[1] O. Helm, *Records, Geol. Surv. Ind.*, xxv, 180 (1892), and xxvi, 61 (1893).

is consequently known to the mineralogist as succinite, but the Burmese amber contains no succinic acid, though the products of its dry distillation include formic acid and pyrogallol. Its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety simetite.

Apart from the occurrence of a large percentage of discoloured and opaque pieces, many of the large fragments obtained are damaged by cracks filled in with calcite; but otherwise there appears to be a large quantity of material which might be put on the market with profit. At present it is said to be unable to withstand the competition of imported Prussian amber, even in the Mandalay bazar, and the market has to a certain extent been depressed by cheaper foreign material and by an artificial substance re-made from amber chips.

Antimony.

Prospecting operations for antimony-ores, amongst which stibnite is the most prominent, have been carried on in South Burma, and in Lahoul, where a large deposit occurs near the Shigri glacier. The latter occurrence is included in a mining lease recently granted, and an attempt is about to be made to mine the ore.

Much of the material sold in the bazars under the name *surma* includes galena as well as antimony, and the word has the same wide significance which the term "black lead" once possessed.

Arsenic.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both Indian and foreign arsenic, presumably in the form of the white oxide.

Table 56 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately.

TABLE 56.—*Average Annual Exports and Imports of Arsenic for the years 1897-98 to 1902-03.*

—	Quantity.	Value.
	Cwts.	
Exports of Indian Arsenic—		
To Straits Settlements	308	
„ Other Countries	26	
TOTAL .	334	£ 525
Imports of Foreign Arsenic—		
From the United Kingdom	421	
„ „ Germany	829	
„ „ China	909	
„ „ Straits Settlements . . .	99	
„ „ Other Countries	88	
TOTAL .	2,346	£ 3,110
Re-export of Foreign Arsenic	111	

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the six years 1897-98 to 1902-03, the average annual imports across this frontier amounted to 9,551 cwts., at an estimated value of £11,470, or 24 shillings per cwt. The last three years have shown a decided increase in the trade, with, however, an average reduction in the price per cwt. (see table 57).

Orpiment.

TABLE 57.—*Imports of Orpiment from Western China.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	Shillings.
1897-98	3,165	4,534	28·65
1898-99	5,253	7,523	28·64
1899-00	8,712	11,582	26·59
1900-01	12,075	14,822	24·55
1901-02	17,268	21,195	24·55
1902-03	10,831	9,163	16·92
Average	9,551	11,470	24·02

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work, in which the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. It is used also for the designs on the Afridi wax-cloths.[1]

Asbestos.

Asbestos has not yet passed beyond the prospecting stage in India, although attempts have been made, during the past three or four years, to work the occurrences in Merwara, Rajputana, Garhwāl in the United Provinces, and Hassan in Mysore.

Borax.

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which, during the last six years, has averaged annually 4,481 cwts., of a value of £6,370 (table 58), is practically all obtained from Tibet, being imported across the frontier into the Punjab and United Provinces. The word *tincal*, by which it is known in the bazars, is possibly a corruption of the Tibetan name for borax, and is in common use on the Punjab frontier, where one meets,

[1] G. Watt, Indian Art at Delhi, 1903, pp. 211, 221, 222, 231.

in the Himalayan passes, herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 58.—*Exports of Borax by Sea from India during the years 1897-98 to 1902-03.*

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1897-98	3,624	*184*	4,339	23·95
1898-99	4,999	*254*	6,429	25·72
1899-00	4,405	*224*	6,304	28·62
1900-01	3,190	*162*	5,020	31·47
1901-02	5,666	*288*	8,594	30·34
1902-03	5,002	*224*	7,534	30·12
Average	*4,481*	*228*	*6,370*	*28·43*

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, and Kalat. During the six years, 1897-98 to 1902-03, these trans-frontier exports of borax have averaged 23 cwts. a year, with an average total value of Rs. 377 (£25) or Rs 16·4 (22*s.*) per cwt. The export trade has very seriously declined. Twenty years ago the borax sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the principal part of the material exported went to the United Kingdom (14,134 cwts. in 1883-84), but with the discovery of large deposits of calcium borate in America the demand for borax from India ceased, and now the only large customers are in the Straits Settlements and China, the latter having taken 3,827 cwts., and the former 468 cwts., of the average annual total of 4,481 cwts. exported.

The amount of borax imported into India across the frontier has averaged (as shown in table 59) 21,955 cwts., of the value of £17,369; adding to this the small quantity of refined material imported by sea, namely, an average of 214 cwts., it is seen that the consumption in India has averaged 17,655 cwts. per annum during the years 1897-98 to 1902-03.

TABLE 59.—*Imports of Borax by Land during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	Shillings.
1897-98	15,273	12,097	15·84
1898-99	16,564	13,053	15·76
1899-00	20,315	16,424	16·17
1900-01	18,621	15,065	16·18
1901-02	31,085	24,096	15·50
1902-03	29,874	23,482	15·72
Average	*21,955*	*17,369*	*15·82*

Of the amounts brought across the frontier, and shown in table 59 to have an annual average of 21,955 cwts., 1,117 cwts., or 5·1 per cent., came from Ladakh, whilst 20,831 cwts., or 94·9 per cent., came from Chinese Tibet.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs, associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the World, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building-Stone.

If the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building-stone, road-metal and clays used in India was abandoned when it was shown in 1899 that the returns could not possibly rank in value much above mere guesses. The same remark might possibly apply to any other country, where figures are regularly reported, though they are of little value for comparative purposes on account of the varying systems of making estimates.

In the United Kingdom, where land is generally sufficiently valueable to cause an increase of depth in quarrying to be less expensive than horizontal extension, a large proportion of the quarries come under the control of the Mines Acts, and regular returns for production are consequently available; but in India there are only a few quarries of more than 20 feet in depth, and the returns from them represent an unimportant fraction of the total amount of material which is being raised all over the country for public works of all kinds. For the present, therefore, we must be content with a general statement to represent the changes from one period to another.

In the absence of statistics, it is difficult to express shortly the trade in material so widespread as common building-stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are largely used. In Central India, Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, whilst in Bengal the Gondwana sandstones are used on, and within easy distance of, the coal-fields.

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called kankar and laterite, are about the most valuable assets in building material possessed by the country.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental architecture. In the great alluvial plains, buildings of importance are naturally most often made of brick, but the margins on all sides admit of a certain inward diffusion of stone, which has been extended by increased facilities for transport. In this respect it is interesting to see that at last the monotony of brick buildings in Calcutta is being relieved by the introduction of the Vindhyan sandstones of Mirzapur, and the calcareous freestones and buff traps brought from the west coast. But the use of Italian marble, mainly for floorings, and, in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have been persisted in mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market in a manner suitable to the immediate requirements of the builder and architect. It is thus not because of the dearth of natural resources, but it is on account of the want of enterprise, that Indian ornamental building stone is less used in the chief cities.

During the six years under review the stone and marble imported from foreign countries into India had an average annual value of £19,848, and of this amount the value of marble from Italy was £10,221, or 51·5 per cent. of the average annual total. It is naturally surprising to find that a country which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people, is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty, which has existed in India since the wonderful Buddhist topes of Sanchi and Bhahrut were erected, has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture.

A recent development of importance has occurred in quarrying the nummulitic limestones of the Khasia and Jaintia hills, partly for use in the manufacture of lime or for use as simple limestone, and partly for the manufacture of cement near Calcutta. In 1898 the amount of limestone quarried in this district was estimated at 61,105 tons, but considerable fluctuations were shown in subsequent years with a general improvement to 88,675 tons in 1903.

For some of the quarries in Lower Vindhyan limestone near Katni, which have come under the control of the Indian Mines Act, returns are available since 1901, when the quantity raised was 28,000 tons, followed by 30,091 tons in 1902, and 35,238 tons in 1903. A limestone of Upper Vindhyan age is being worked near Sutna by a joint stock company, but much of the material is carried by rail a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

Chromite.

Chromite is known to occur with the peridotites of the Chalk hills near Salem, in the Andamans, and in Baluchistan. Attempts were made long ago to work the deposits near Salem, but nothing has been done since. In Baluchistan the ore occurring in the Pishin and Zhob districts is being opened up for export, the output for the first year of work, 1903, being returned as 284 tons. Larger quantities are now being raised, the amount for the first half of 1904 being 1,816 tons.

Clays.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. They include the common clays used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and fuller's earth, which is mined in the Central Provinces and in Rajputana.

The imports of materials coming under this head show that there is room for the development of the raw materials which are suitable for the manufacture of articles required in a modern civilized community. In 1903 the value of earthenware and porcelain imported amounted to £187,390; of earthenware piping, £6,659; of clay, £6,186; and of bricks and tiles, £38,618.

Copper-ores.

Copper was formerly smelted in considerable quantities in South India, in Rajputana and at various parts of the outer Himalayas where a killas-like rock persists along the whole range, and is known to be copper-bearing in Kulu, Garhwal, Nepal, Sikkim, and Bhutan. Native-made copper has, however, completely given way to the imported material, and all attempts by European companies to open up the deposits have proved to be unsuccessful so far. Mining leases are still held, and prospecting licenses frequently granted for copper ores. The Indian purchases of copper and brass form a sensible item in the imports of metals. During the six years under review the average annual value of copper imported was £813,701, whilst during the last three years the copper imported was valued at over a million sterling per annum.

Corundum.

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, like hercynite, have been used inadvertently as such. During the last ten years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached about 1,700 tons a year. Artificial corundum is also being manufactured from bauxite at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer, sword-grinder) and lapidary has been known for many generations, the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewa. In 1898, the figures returned showed a production of 7,603 cwt., but the output never approached this figure in any subsequent year.

Corundum is very widely distributed throughout the Mysore State, and is said to occur in every district except Shimoga. The annual production in Mysore has been estimated as follows:—

			£
1898	2,937 cwts., valued at	. . .	698
1899	879 "	" " . . .	171
1900	1,386 "	" " . . .	225
1901	1,634 "	" " . . .	357
1902	574 "	" " . . .	108

Much of the corundum, which is a regular item of trade in the bazars of cities like Delhi, Agra and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cow-herds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarized in a special memoir published by the Geological Survey in 1898.

Since that year interesting developments have occurred in working the corundum in Ontario, Canada, where the mineral occurs in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[1] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe. The output of Canadian corundum in 1902 reached 805 tons, which was about double the production of 1901.

Gem-stones.

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of £511,206.

Of the precious and semi-precious stones in India, the most important, Amber, Jadeite and Ruby, have been already referred to. Of

[1] T. H. Holland: The Sivamalai series of Elæolite and Corundum-Syenites, *Mem. Geol. Surv., Ind.*, XXX, pt. 3, 1901.

the others, the only ones which are of immediate concern are Beryl, Diamond, Garnet, Sapphire, Spinel, Tourmaline, and Turquois. All of these except the last have been, or are still being, worked to some extent in India, and the Turquois may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals deserve more particular mention.

Agate.

There is still a considerable trade in agate and the related forms of silica, known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and perhaps still the most important of the places at which agate and carnelians are cut and prepared for the market is Cambay, the chief city of the state of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various states and districts on or near the edge of the trap, but mostly from the State of Rajpipla, where the chief source is a conglomerate near the village of Ratanpur. The right to collect *hakik* at Ratanpur is leased for a period of five years at a fixed annual rental, but precise data as to the value of the stones sent to Cambay are not obtainable. A certain amount of agate-cutting is also carried on at Jabalpur, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as "Vallum diamonds," whilst the bi-pyramidal quartz-crystals found in the gypsum of the salt marl near Kalabagh, on the Indus, are to a certain extent used for making necklaces, and rock-crystal is similarly used for cheap jewellery in Kashmir.

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Behar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aqua-marines; but the only places in India where attempts have been made to excavate pegmatite solely for its aqua marines are at Padyur (Pattalai) near Kangayam, Coimbatore district, and at different places in the Toda hills in Rajputana. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30—40 feet in depth is still in existence, but no one seems to have taken an interest in the place since J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions, and deserves more attention than it has so far received.

Diamonds: Distribution of, in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probably pre-Cambrian age now known as the Purána group, and distinguished locally as the Cuddapah and Kurnool systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Bellary, Kurnool, Kistna, and Godavari. Loose stones have been picked up on the surface of the ground, found in deposits of alluvium and in workings which have been undertaken in the so-called Banaganpilly stage of the Kurnool series of strata.

Eastern group of occurrences.

In the second group of occurrences in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, and though strata similar to those of the Vindhyans and Kurnools are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in deposits which, though described as alluvium, are possibly relics of Lameta (Upper Cretaceous) deposits.

Garnet.

The only garnets worked to any considerable extent in India occur in the mica schists of Rajmahal in Jaipur, and near Sarwar in the adjoining State of Kishengarh.

Returns are not available to show the condition of the industry in Jaipur, but there is still a considerable industry in the Kishengarh State, though the yearly estimates are altogether too variable to permit of a fair average being drawn, varying from about £10,000 to £2,000.

Sapphire.

Sapphires of considerable value were formerly obtained in Zanskar, Kashmir State, but the mines are said to be exhausted, and returns for recent work are not available. Occasionally the normal blue sapphire, and the rarer green, yellow and white varieties are found in the ruby-bearing gravels in Burma.

Spinel.

Spinel is a constant associate of the ruby, both in the gravels and in the limestone, and the crystals, on account of their perfect ruby colour and their octahedral habit, are often mistaken for the true ruby with its eight-faced combination of the basal plane and rhombohedron.

Tourmaline.

Several attempts have been made to work the beautiful red variety of tourmaline (rubellite) which occurs in the Ruby Mines district of Upper Burma. In 1898 an out-turn worth £359 was reported for this area, in 1900 the value was estimated at £1,240, and in 1903 at £196, but returns are not available for 1899 and 1902.

Gypsum.

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gáj beds of the Kirthar range; in Cutch it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt-marl, lying below Cambrian beds. A very interesting, and, judging by the returns, important occurrence is N.-N.-W. of Nagore in Jodhpur, Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. From this area an annual average output of 5,394 tons is reported for the years 1898 to 1903. Selenite crystals of similar origin have been recently found in the kankar near the base of the silt in the Sambhar lake.

Glass-making Materials.

The common, impure sands of the rivers and the efflorescent alkali salts, so common in many parts of India, are used in various places for the manufacture of the inferior varieties of glass used for bangles; but attempts to make the better kinds of glass on a large scale have hitherto failed in India.

The chief difficulty in the way of manufacturing the better grades of glass in India is the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. For the finer qualities of glass, the sand which is, of course, the chief natural substance used, should be rather fine and uniform in grain, angular rather than rounded, and perfectly white. For the commoner kinds of glass, in which colour is of no importance, a considerable quantity of impurity can be tolerated and allowed for in making up the melting charge. The well-known Fontainebleau sand of France, used largely for glass-making, will yield as much as 99 per cent. of silica, with 0·50 per cent. of alumina and a trace of iron oxide; but good window glass can be made from sand containing iron oxide up to ·02 per cent. without the use of the corrective manganese oxide.

To what extent a glass-making industry would find a market in India may be judged by the fact that during the past six years the annual imports of glass and glassware have gradually risen in value from £441,529 in 1898-99 to £661,377 in 1903-04.

Lead, Silver, and Zinc.

Galena alone, or with blende and other sulphide ores, is known in various parts of India and Burma, and has been worked in various places for lead, or lead and silver, under past Native rulers; but the mining of lead-ores has long been extinct, and the only recent attempt calling for special mention is that now being made to develope the deposits near Pang Yung in the Northern Shan States formerly worked by the Chinese, who left behind large heaps of slag reported to be amenable to profitable treatment by modern metallurgical processes for the extraction of silver.

Millstones.

The manufacture of millstones is almost universal in India, any local hard stone being turned to account. On the plains small millstones of about 15 inches in diameter are worked by hand, but in the Himalayas, where a fall of water can be easily arranged, a rude form of turbine is made to work a heavier stone by a direct-acting vertical shaft, and the ordinary meal of the hill-man is manufactured in these primitive mills. These small mills are familiar objects in a Himalayan valley, but no returns are available to gauge the industry of stone-cutting.

Mineral Paints.

Up to the present the manufacture of mineral paints appears to be very small compared to the demand and the natural resources in minerals apparently suitable. In the Jabalpur district mineral paint-works are utilizing the soft hematites of Jáuli and are drawing supplies of yellow ochre from the Panna State, whilst similar works near Calcutta are dependent largely on imported material.

Ochres, red, yellow and of other colours, are commonly used by natives in many parts of the country, in a crude or simply levigated form and are known under the generic name *geru*. A common source of supply is the laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hematites. In Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma large deposits are known amongst the Tertiary beds of the Myingyan district. A black slate near Kishengarh has been successfully tried on the Rajputana-Malwa Railway. Barytes, used as a substitute or adulterant for "white lead," is obtainable in quantity near Alangayam in the Salem district and in the Jabalpur district, but no attempts have been made to turn the deposits to account for paint-making.

Orpiment, the yellow sulphide of arsenic, has been already referred to under "Arsenic" (*supra*, p. 97.)

Mineral Waters.

One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all railway refreshment rooms. Natives of India have for many ages recognised a value in mineral waters and in the hot springs which are often charged with more than usual quantities of mineral matter. In many cases these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the hot springs at Manikarn in Kulu, where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbatti river. The water is led into the neighbouring temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115°F., are also resorted to by Hindu pilgrims. Generally it may be said that hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side, of India, the distribution being similar (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foothills of the Himalayas, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakhund in the Kharakhpur hills is the only one which has been turned to account.

Phosphates.

One regretful feature in connection with the Indian mineral resources is the absence, in a country where agriculture is such a predominant industry, of any phosphatic deposits of value, and a further circumstance to be regretted is the continued export of phosphates in the form of bones, due primarily to the fact that, being without means for the manufacture of cheap sulphuric acid, superphosphates are not made in the country, and the little that is used is imported from Europe. During the past six years the materials imported under the head of manures have varied in value from £6,367 in 1898-99 to £2,144 in

1902-03, whilst the exports of manures, amongst which bones make up 99 per cent. of the total, have been as follows:—

TABLE 60.—*Exports of Manures from India during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.
	Tons.	£
1897-98	72,664	263,500
1898-99	74,971	272,268
1899-00	110,927	408,581
1900-01	113,465	394,228
1901-02	94,243	344,128
1902-03	105,634	381,784
Average	*95,317*	*344,081*

Amongst the phosphatic deposits of India, the principal and perhaps the only one worth considering is the deposit of phosphatic nodules of the septarian kind, occurring in the Cretaceous beds of the Perambalur taluk, Trichinopoly district, Madras Presidency. Dr. H. Warth in 1893 estimated that to a depth of 200 feet the beds contained phosphates to the amount of about 8 million tons, but the nodules are distributed irregularly through clay, varying, in the different deep excavations made, between 27 and 47 lbs. per 100 cubic feet, and in some shallow diggings 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate, and about 16 per cent. of carbonate of lime, with considerable variations in different nodules. The alumina and oxide of iron vary between 4 and 8 per cent.

Two attempts made to dispose of these phosphates in a finely powdered condition for use as a fertilizer on coffee plantations in South India were reported to be unprofitable, and mining leases have consequently not been applied for. No attempts have been made to export the material. Its value would possibly be about the same as a third-grade Algerian phosphate, which brings about £1 a ton delivered at European ports, and as the sea freight from Madras would be added to the cost of a railway journey of 248 miles and cartage of 20 miles, there is no present prospect of profitable mining for export.

Small quantities of apatite are turned out and thrown away with the waste in the Hazaribagh and Nellore mica-mining areas, and a few other occurrences of unknown, and presumably smaller, value have been reported at different places—near Mussoorie, in East Berar, and in the eocene shales above the coal near Dandot colliery in the Punjab Salt Range.

Rare Minerals.

Minerals of the so-called rare metals have received hitherto practically no attention in India, although some are known to exist in the country, and others, judging by the geological conditions, might be hopefully searched for. Molybdenite has been found as isolated crystals in pegmatite and quartz-veins in parts of Chota Nagpur; tungsten occurs in the mineral wolfram as a common associate of tin-ores in South Burma and in the Southern Shan States; platinum and iridium have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Assam and the Burma sides; uranium-ores have been detected in the mica-bearing pegmatites of the Singar mica mine in the Gaya district, occurring as pitchblende, torbernite and uranium-ochre; titanium is widely distributed in the form of ilmenite and sphene; and zircon occurs associated with the elæolite-syenites in the Coimbatore district. Of these minerals possibly the wolfram (tungstic ore) of Burma offers the best prospects of immediate development.

No undoubted occurrence has been recorded of the minerals which are valuable, like monazite and the new Ceylon mineral thorianite, on account of the incandescent rare earths they contain, although some of these minerals are very widely distributed amongst crystalline rocks resembling those of Peninsular India. Columbite, tscheffkinite, gadolinite, and allanite containing helium have, however, been definitely determined in India.

Slate.

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay slates, possess an even and perfect fissility which enables them to be split for slabs and even fine roofing slates. In the Kangra district a joint-stock company has organized the work in a systematic manner, and for the past six years has declared dividends of 12 per cent. with the addition of considerable sums to the reserve funds. The same company works quarries in clay-slate amongst the Aravalli series near Rewari, south of Delhi.

In the Kharakpur hills, a private company is working a slightly metamorphosed phyllite, which, though not giving the thinnest varieties of roofing slate, produces fine slabs, for which a more extended use is continually being found. Slate is also being worked in various parts of the so-called transition series of rocks on the Peninsula; but no figures are available to show the extent of the trade.

Sodium Compounds.

Besides sodium chloride other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, and both the sulphate and carbonate are prominent amongst the sodic compounds in the brine of the Rajputana salt lakes. A conspicuous instance of a salt lake in which the carbonate is most prominent is the crater-like Lonar lake occurring as a roughly circular depression in the Deccan trap-flows of Berar.

Besides the impure *sajji-matti*, of which considerable quantities are still in use, the trade statistics show that imports are distinctly increasing, and that common country *sajji* is becoming displaced. For information concerning the alkali compounds used and manufactured in India, see *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta.

Steatite.

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so-called on account of its general use in making pots, dishes, etc.,—or in the more compact form suitable for carvings, and in its best form, suitable for the manufacture of gas-burners. There is a trade of undetermined value in nearly every province, but it is impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records*, *Geological Survey of India*, vol. XXII, part 2 (1889), and a note by Mr. H. H. Hayden in vol. XXIX (p. 71) of the same publication adds further details with regard to the deposits in Minbu district, Burma, where the annual outturn is estimated to be worth from £300 to £500. The returns, which are confessedly incomplete, give an average annual production in India of about 35,000 tons, valued at £1,900.

Sulphur, Sulphur c Acid, and Soluble Sulphates.

Sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island, and on some of the volcanoes in Western Baluchistan, whilst it has been reported in connection with the petroliferous Tertiary rocks in the Baluchistan-Persian belt, as well as in the Arakan system on the east. There are, however, no deposits of free sulphur known to be worth working.

Pyrite is known in various parts of India, and in one place, near Kalabagh on the Indus, it is sufficiently abundant in the shales which have been worked for alum to give rise to frequent cases of spontaneous combustion. An occurrence of this sort is one that, suitably placed, might be of value as a source of sulphur. Otherwise, the only chance of sulphur to compete with the imported article is bound up in the problem of developing the metalliferous sulphides for both metal and sulphur.

Sulphuric acid.

In view of the value of the imports of sulphur and sulphuric acid, and in consideration of the fact that a cheap supply of the acid would be the key to many industries now either non-existent or in a feeble condition, the manufacture of sulphuric acid on a large scale and cheaply would be the starting point of an economic revival. During the six years under review the imports of sulphur averaged 34,136 cwts. a year, valued at £12,612, whilst the annual average for sulphuric acid was 45,374 cwts., valued at £32,273. A small quantity of the acid, on an average 250 cwts. a year, was re-exported, chiefly to British East Africa. In addition to sulphuric acid, there are several chemicals imported which could be produced in India more cheaply if the acid were made in the country in large quantities at a sufficiently low price. The average annual value of imported " chemicals for paper-making " alone has been £54,810 during the past six years, and if, as seems likely, an attempt is made to turn the bye-products in coke-making to account, the demand for sulphuric acid will increase, whilst the only chance of these industries springing up will depend on the possibility of obtaining a cheap supply of sulphuric acid.

Sulphates of iron and copper.

For many years pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, p. 94), and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe.

Through the accident of an alphabetical arrangement, the last subject to be considered enables us to point the lesson taught by a general survey of progress (*cf.* page 7). Sulphuric acid is the key to most chemical and to many metallurgical industries; it is essential for the manufacture of superphosphates, the purification of mineral oils and the production of ammonium sulphate, various acids, and a host of minor products; it is a necessary link in the chain of operations involved in the manufacture of the alkalies, with which are bound up the industries of making soap, glass, paper, oils, dyes and colouring matters; and, as a bye-product, it permits the remunerative smelting of ores which it would be impossible otherwise to develop. During the last hundred years the cost of a ton of sulphuric acid in England has been reduced from over £30 to under £2, and it is in consequence of the attendant revolution in the European chemical industries, aided by increased facilities for transport, that in India the manufacture of alum, copperas, blue vitriol and the alkalies have been all but exterminated; that the export trade in nitre has been reduced instead of developed; that copper and several other metals are no longer smelted; that the country is robbed every year of nearly 100,000 tons of phosphatic fertilizers; and that it is compelled to pay over 10 million sterling for products obtained in Europe from minerals identical with those lying idle in India.

Although sulphuric acid and the alkalies are essential to so many other industries, the conditions for their profitable manufacture will balance the "protective" effect of transport charges only when there is a market in the country for the bye-products which are now essential parts of the cycle of operations in a chemical industry. These conditions, as shown by the import statistics, are rapidly ripening, but the enterprising capitalist should remember, also, that the present requirements of India represent but a fraction of the consumption which will follow any material reduction in prices by local production.

LIST OF PLATES.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1905. [September.

NOTES ON AN ANTHRACOLITHIC FAUNA FROM THE MOUTH OF THE SUBANSIRI GORGE, ASSAM. BY PROF. C. DIENER, PH.D., *of the Vienna University*. (With Plate 8.)

A PAPER published by Mr. J. Malcolm Maclaren in the Records of the Geological Survey of India (Vol. XXXI, Pt. 4) gives a detailed report on the progress of his geological survey in N.-E. Assam. During his survey some fossils, supposed to be of permo-carboniferous age, were obtained by him in boulders in the Subansiri river at Derpai, near the mouth of the Subansiri gorge, North Lakhimpur, Assam. Provisional determinations of the fossils were made by Mr. G. H. Tipper.

The Subansiri valley being an impenetrable jungle occupied by hostile tribes, every fragment of evidence may be considered valuable until this almost unknown area is more thoroughly explored. In view of the interest connected with the problem of a relation between the coal-bearing Gondwanas of Assam and marine beds of Permo-Carboniferous (Anthracolithic) age,[1] Mr. T. H. Holland, Director of the Geological Survey of India, had Mr. Maclaren's fossils sent to me for examination, and asked me to determine them and to prepare a paper for the *Records*. I am greatly obliged to him for entrusting this interesting material to me.

[1] I prefer to use the term "Anthracolithic" under which I understand both the Carboniferous and Permian systems. The reasons for adopting this denomination introduced by W. Waagen, have been detailed in my memoir on the Anthracolithic fossils of Kashmir and Spiti. (*Palaeont. Indica*, ser. XV, Himál. Foss., Vol. I, Pt. 2, p. 1).

The fossils were all obtained from a small number of boulders occurring in the bed of the Subansiri. From the differences in the matrix and the state of preservation of fossils the rock-specimens may be divided into two groups:—

(*a*) Matrix arenaceous and only slightly calcareous. The fossils are, as a rule, very badly preserved as weathered casts and subjected to considerable crushing.

(*b*) Matrix extremely hard, blue, argillaceous limestone nodules, recalling the limestone nodules in the Kuling shales of Lilang (Spiti) with *Cyclolobus div. sp.* They are rich in casts of *Chonetes carbonifera* Keyserl. Together with them other fossils occur, but, as a rule, their impressions only are preserved, the fossils themselves having been entirely destroyed. By making plaster-casts of the impressions, I have succeeded in obtaining several examples allowing a satisfactory determination.

The impressions of *Crinoidea* in one of the boulders are of a rather remarkable habit. The stems have been destroyed entirely, but a cast has been left of the interior canal in the shape of a long column, provided with numerous projecting annuli.

A.—FOSSILS FROM THE ARENACEOUS ROCKS.

PRODUCTUS CF. PUSTULOSUS, Phill. Fig. 1.

1836. *Productus pustulosus* Phillips, Geology of Yorkshire, Vol. II, p. 216, Pl. VII, fig. 15.

For a complete list of synonyms I refer to my memoir on the anthracolithic fossils of Kashmir and Spiti, *Palæontologia Indica*, ser. XV, Himál. Foss., Vol. I, Pt. 2, p. 34.

The impression of a dorsal valve, incomplete as it is, agrees closely with the dorsal valves of *Productus pustulosus*, as illustrated by Davidson on Pl. XLI of his monograph of British carboniferous Brachiopoda. The impression is slightly depressed in the middle, this depression corresponding to a small mesial fold in the cast, and is covered with numerous concentric wrinkles. The spaces between the concentric wrinkles are interrupted by numerous coarse pustules, which are often square-shaped and arranged irregularly.

PRODUCTUS DIV. SP. IND. Fig. 2.

There are numerous casts of *Producti* among Mr. Maclaren's fossils. They do not permit of a specific identification, but are valuable as evidences of the Anthracolithic age of the Subansiri fauna.

A large cast of a ventral valve reminds one of the group of *Productus Cora* d'Orb.

Three casts show the interior of dorsal valves, with the median septum, adductor and reniform impressions partly preserved. One of those casts has been illustrated in fig. 2.

SPIRIFER DIV. SP. IND.

The genus *Spirifer* is rather richly represented among the fossils from the mouth of the Subansiri gorge, but all specimens are agmentary and only internal casts devoid of their shelly substance. ong them some transversely fusiform shapes with widely expanding have been noticed, reminding one of *Spirifer alatus* Schloth., *p. convolutus* Phill.

.e cast of a large dorsal valve, measuring at least 115 mm. in width, shows strong and coarse ribs with distinctly triangular sections and sharp edges, and a strongly elevated mesial fold, which has been severely injured. It recalls *Spirifer convolutus* Phill., *Sp. trigonalis* Mart., or *Sp. vespertilio* Sow.

SPIRIFERINA SP. IND

A weathered fragment of a ventral valve reminds one of *Spiriferina Kentuckensis* Shum., or of *Sp. insculpta* Phill. It is greatly extended transversely and provided with rounded plications, which are crossed by numerous lamellæ of growth.

RETICULARIA CF. INÆQUILATERALIS (?) Gemmellaro.

1899. *Reticularia inæquilateralis* Gemmellaro, La fauna dei calcari con Fusulina della valle del F. Sosio, Fasc. IV, Pt. I, p. 336, Tav. XXXV, figs. 2-21. LXVI, fig. 13.

1903. *R. inæquilateralis* Diener, Himálayan Fossils, *Palæontologia Indica*, ser. XV, Vol. I, Pt. 5, p. 23, Pl. I, fig. 6.

A single cast without any trace of its shelly substance is provisionally and with much hesitation referred to *Reticularia inæquilateralis* as comparable on account of its remarkable similarity with this species.

That the cast belongs to the family of *Spiriferidæ* or rather to one of the subgenera of *Spirifer* distinguished by their smooth shells, is pretty certain. The general shape of the two valves, the presence of a large, slightly incurved beak in the ventral valve, the short hinge-line, and the indistinctly marked-off area with its deltoidal fissure are all characters agreeing with the group of *Spirifer lineatus* Mart.

With *Reticularia inæquilateralis* from the permian rocks of Sicily and of the Tibetan region of exotic blocks in the Himálayas, the present species agrees in the remarkably asymmetrical shape of the valves and in the position of the apex, which is shifted to the right, the specimen having been placed into its proper position, front margin upwards.

A mesial sinus is marked by a shallow impression in the ventral valve. Traces of concentric lines of growth have been noticed.

Whether this species of *Reticularia* really bears such close affinities to *R. inæquilateralis*, as I am inclined to suppose, cannot be decided. The fossils from the arenaceous boulders being very often crushed and deformed, its asymmetrical shape may, perhaps, be accidental only and due to pressure in the rocks.

DIELASMA SP. IND. AFF. URALICO Krotow. Fig. 8.

The fairly well preserved cast of a ventral valve reminds one very strongly of the Russian *Dielasma uralicum* Krotow (The Artinskian stage, Mem. Soc. of Naturalists Kasan, Imper. University, Vol. XIII, Pt. 5, 1885, p. 287, and Geologische Forschungen am westlichen Ural-Abhange in der Gebieten von Tscherdyn und Ssolikamssk, Mém. Comité géol. St. Pétersburg, 1888, Vol. VI, p. 429, Pl. I, figs. 33-36). It is strongly curved, bordered by straight lateral margins, which unite in the partly broken-off beak under a very sharp angle, and is provided with a high and regularly vaulted mesial elevation. This median elevation increases in width towards the front, where it terminates in a strongly protracted tongue. It is accompanied on each side by a flatly arched depression, above which the marginal region of the valve is slightly elevated.

The present cast differs from Krotow's type-specimen by larger dimensions, by a narrow mesial fold and by broader lateral wings. But those differences are of small importance only compared to the general agreement of the two shells. This Indian species is certainly most nearly allied to *Dielasma uralicum*, which for its peculiar characters is one of the most remarkable types of the genus.

Its affinity to the Russian form is much stronger than to *Dielasma La Touchei* Diener (Himálayan Fossils, Vol. I, Pt. 5, p. 111, Pl. V, figs. 7-9), from which it is easily distinguished by its different outlines. *Dielasma La Touchei* is nearly triangular, with a slightly emarginated front-line, the angles of which correspond to the greatest transverse diameter, whereas in the present cast the outline is trapezoidal and the greatest breadth occurs in the second fifth of the entire length of the shell.

The measurements of this cast are as follows:—

Length	of the ventral valve	28 mm.
Breadth	of the ventral valve	22 „
Thickness	of the ventral valve	15 „

DIELASMA SP. IND. EX AFF. D. BIPLEX, Waagen. Fig. 7.

A cast of a ventral valve recalls in its outlines and in the presence of a median ridge the group of *Dielasma biplex* Waagen from the Productus limestone of the Salt Range (Productus limestone foss., Palæontologia Indica, ser. XIII, Vol. I, p. 349).

It cannot be identified with any of the species illustrated by Waagen on Pl. XXV of his memoir, but probably belongs to a new species. It is of larger size than *D. biplex*, a longitudinal diameter of 45 mm. corresponding to a transverse diameter of 32 mm. The mesial ridge is more strongly developed and originates in the apical region The greatest width occurs nearer to the front. The outline is distinctly pentagonal, with a biplicate front-line. By this character the present cast is easily distinguished from *Dielasma La Touchei* Diener, of which it reminds one in the development of a comparatively high and narrow mesial ridge.

DIELASMA SP. IND.

An imperfect cast suggests *Dielasma ficus* McCoy, but has its dorsal valve provided with a sharp mesial edge, from which the shell slopes obliquely towards the marginal region. The bad state of preservation does not allow of a decision as to whether this character is, indeed, a specific feature or only accidental.

B.—FOSSILS FROM THE HARD, BLUE, ARGILLACEOUS LIMESTONE NODULES.

CHONETES CF. CARBONIFERA Keyserling. Figs. 3-6.

1845. *Chonetes sarcinulata* Verneuil, Géologie de la Russie d'Europe II. Paléontologie, p. 272, Pl. XV, fig. 10.
1846. *Chonetes sarcinulata var. carbonifera* Keyserling, Reise in das Petschoraland, p. 215.

1876. *Chonetes variolata* Trautschold *ex parte*, Die Kalkbrüche von Miatschkows, II, p. 67; I. Pl. VII, figs. *a-c*.

1890. *Chonetes pseudovariolata* Nikitin, Dépôts carbonifères, et puits artésiens de la région de Moscou, Mém. Comité Gécl. Pétersburg, Vol. V, No. 5, p. 27; Pl. II, figs. 1-3.

1898. *Chonetes pseudovariolata* v. Lóczy, Wissenschaftliche Ergebnisse der Reise des Grafen Béla Széchényi in Ostasien, Bd. III, Abt. IV, p. 73, Taf. III, figs. 8-12.

1902. *Chonetes carbonifera* Tschernyschew. Die obercarbonischer Brachiopoden des Ural and des Timan. Mém. Comité Géol. St. Pétersburg, Vol. XVI, No. 2, pp. 233, 595.

1903 (?) *Chonetes pseudovariolata* Schellwien in Futterer "Durch Asien" III, Bd., Abt. 3, p. 142. Taf. I, figs. 5-8.

This species is represented by numerous and fairly well preserved casts of both valves. They agree most closely with the Chinese specimens figured by L. v. Loczy and identified by him with *Chonetes pseudovariolata* Nikitin. All of them are of small size with rectangular outlines and rounded-off frontal corners.

The ventral valve is moderately inflated and not sinuated, but occasionally provided with a very flat mesial depression only. The dorsal valve is flatly concave.

The majority of my specimens are casts, with fragments of the shelly layer preserved. From plaster casts of impressions, however, a fairly good idea of the ornamentation of the shell may be got. The shell is covered with numerous and thin, thread-like, radiating striæ, which increase in number from the apex to the front by bifurcation. None of my casts is sufficiently well preserved to allow the presence of concentric striæ of growth to be noticed. The casts devoid of their shelly layer are covered with numerous grooves, arranged radially along the intercostal spaces.

The deep median septum of the ventral and the two converging hinge-plates of the dorsal valve are distinctly marked.

There is no species of *Chonetes*, to which the specimens from the Subansiri gorge show an equally close affinity as to *Chonetes carbonifera* Keyserl. The absence of a distinct sinus excludes an identification with *Ch. variolata* d'Orbigny (voyage dans l'Amérique méridionale, Vol. II, Paléont., p. 49, Pl. IV, figs. 10, 11) or with any of the Indian types of the group of *striatæ* hitherto described. With *Ch. granulifera* Owen (Meek in final report of the United States Geological Survey of Nebraska, p. 170, Pl. IV, fig. 9; Pl. VI, fig. 10: Pl. VIII, fig. 7, they cannot be identified, on account of the absence of strongly expanding rings. From *Ch platynota* White (in Wheeler's report on the United States Geographical Survey of the 100th meridian, Vol. IV, p. 121; Pl. IX, fig. 6) they differ by the curvature of their dorsal valve, which is distinctly concave, not flat or even convex, as in *Ch. platynota*. *Ch. dalmanoides* Nikitin is of much larger size. Among all the asinuated forms of *Chonetes striatæ* it is *Ch. carbonifera* with which the specimens from the Subansiri gorge agree most closely.

For this species, which is widely distributed throughout the upper carboniferous rocks of Europe and Asia, Count Keyserling's original name, *Chonetes carbonifera*, must be retained, as has been argued by Th. Tschernyschew.

MYALINA SP. IND. Fig. 11.

The plaster-cast of an impression of a right valve might at a first glance be mistaken for a *Mytilus*, nearly allied to a species from the Kuling shales of Spiti, which has been illustrated on Pl. VIII, fig. 4, of Vol. I, Pt. 5, of the "Himálayan Fossils" (Palæontologia Indica, ser. XV). But a closer examination revealed the presence of a moderately long hinge-line.

The generic separation of *Myalina* and *Mytilus* has been based on the character of the hinge-line by L. de Koninck (Description des animaux foss. du terr. carbon. de la Belgique, 1842, p. 125). It is short and very narrow in *Mytilus*, but elongated, thickened, and provided with longitudinal grooves in *Myalina*. Of all those characters of distinction enumerated by L. de Koninck only the length of the hinge-line is accessible to examination in my specimen, which, I think, must be classed with the genus *Myalina*. An identification with *Modiola* is excluded by the terminal position of the beak.

Myalina lamellosa de Kon. (Faune du calcaire carbonifere de la Belgique, Annales du Musée d'hist nat. de Bruxelles, T. XI, p. 169; Pl. XXIX, fig. 11) shows a distant similarity with the present species, but the gibbosity of the median part of its umbonal region is more distinctly developed.

MONOPTERIA SUBANSIRICA, nov. sp. Fig. 10.

Among Mr. Maclaren's materials there are a cast and an impression of the left valve of a very remarkable representative of the family of *Pteriidæ* Meek, distinguished by its large posterior wing and by the complete absence of an anterior one. *Pteriidæ* of this kind have been described as *Limoptera* by Hall (Palæontology of New-York, Vol. V, Pt. 1; Lamellibranchiata, p. 243), as *Monopteria* by Meek and Worthen (Geological Survey of Illinois, Pt. II, Palæontology, p. 340). The absence of the anterior wing in my specimens induces me to place them in the genus *Monopteria*, although they differ considerably from the prototype of that genus, *Monopteria gibbosa* Meek and Worthen (l. c., p. 340; Pl. XXVII, fig. 11) from the coal-measures of Illinois.

The plaster-cast of the impression allows a sufficiently good reconstruction of the left valve to justify the introduction of a new specific denomination. The differences in sculpture from *Monopteria gibbosa* are, perhaps, remarkable enough to be considered of subgeneric value, but my materials are too scanty for proposing a new subgeneric name.

Shell of equal height and length. Anterior margin truncate, posterior margin broadly rounded, uniting with the straight hinge-line in a right angle. Neutral margin passing into the posterior margin in a regular curve and meeting the anterior one in a blunt angle. From this angle a sharp edge runs to the beak, separating the vertical anterior part from the remainder of the shell. A second edge running from the beak towards the posterior margin is less distinctly defined.

Median portion of the shell elevated and gibbous along the umbonal slopes. Apex shifted to the anterior termination of the hinge-line, which corresponds to the greatest length of the valve.

Surface covered with numerous concentric lines of growth, which become obsolete along the anterior wall.

The measurements of the illustrated plaster-cast are as follows:—

Length } of the shell	19 mm.
Height } of the shell	19 „
Thickness of the left valve	5 „

LOXONEMA SP. IND. Fig. 12.

A turreted shell with deep sutures and S-shaped growth-lines is provisionally referred to this genus, but its fragmentary state renders it unfit for an exact determination. Neither the apical whorls nor the body-whorl have been preserved. The whorls are somewhat angular in the middle, but the growth-lines are not turned backwards along this angular band as along the slit-band of *Pleurotomaria* and its allies. The sutures are remarkably deep and take the shape of spiral furrows or channels as in *Loxonema Walcidiodorense* de Koninck

(Faune du calcaire carbonifère de la Belgique. Annales Musée Royal d'hist. nat. Bruxelles, T. V, 3ème ptie, p. 55; Pl. V, figs. 5, 6).

PLEUROTOMARIA SP. IND. AFF. PUNJABICA Waag. Fig. 13.

An impression of a *Pleurotomaria* reminds one of this species from the Productus limestone of the Salt Range (Salt Range Fossils, Palæont. Indica, ser. XIII, Vol. I, Productus Limestone Foss., p. 115; Pl. XI, figs. 3, 4) or of the examples of *Pleurotomaria* from the permian Productus (Kuling) shales of the Lissar valley, described and figured in "Himálayan Fossils," Vol. I, Pt. 5, p. 100; Pl. V, figs. 1—3).

The spire is a little less noticeably depressed, but consists of an equally small number of whorls. The profile of the body-whorl is not evenly rounded. The ridges bordering the narrow and angular slit-band are distinctly marked. The zone between the slit-band and the suture of the preceding whorl is covered with a small number of delicate spiral striæ. The lower part of the body-whorl is apparently smooth.

BELLEROPHON SP. IND. Fig. 14.

The cast of a small, bilaterally symmetrical shell, coiled in one plane, undoubtedly belongs to a species of *Bellerophon*. The globose shell is narrowly umbilicated on both sides and exhibits no trace of a slit-band.

FENESTELLA SP. IND. Fig. 15.

Traces of Bryozoa have been noticed in the condition of impressions left by the removal and decay of the polyzoarium. The delicate shape of the colony, with rectangular fenestrules and thin dissepiments reminds one of the *Fenestellæ* from the Zewan-beds of Kashmir and from the Fenestella-beds of Spiti, probably allied to *Fenestella plebeia* McCoy.

CONCLUSION.

Notwithstanding the unsatisfactory state of preservation of the materials from the mouth of the Subansiri gorge, their examination leads to the interesting result, that they contain a marine fauna of Anthracolithic age. This result fully confirms Mr. Holland's suggestion with regard to the relation between the Gondwanas and the marine Permo-Carboniferous strata in N.-E. Assam.[1]

[1] General Report, Geol. Surv. Ind. for 1903-04. *Records*, XXXII, p. 153.

The assemblage of forms does not leave a shadow of doubt about the Anthracolithic age of the Subansiri fauna. The large number of *Producti*, among which a species closely allied to a well-known European one (*Prod. pustulosus* Phill.), has been noticed, the presence of the widely distributed *Chonetes carbonifera* Keyserl., of a species of *Dielasma* nearly allied to *D. uralicum* Krotow, of a *Reticularia* of strongly inequilateral shape, are all characters of great stratigraphical importance. Their value is strengthened by the complete absence of any type which has hitherto been met with in strata of the lower Palæozoic systems.

The fauna is too poor in determinable fossils for me to say anything with regard to its correlation with either Carboniferous or Permian strata.

EXPLANATION OF PLATE 8.

Fig. 1. *Productus sp. cf. pustulosus* Phill. Impression of a dorsal valve.
„ 2. *Productus sp. ind.* Cast of the interior of a dorsal valve, with adductor and reniform impressions and median septum.
„ 3. *Chonetes cf. carbonifera* Keyserling. Dorsal valve with its test partly preserved.
„ 4. *Chonetes cf. carbonifera.* Dorsal valve, with its test partly preserved.
„ 5. „ „ „ Fragment of a ventral valve, with its test partly preserved.
„ 6. *Chonetes cf. carbonifera.* Cast of a ventral valve.
„ 7. *Dielasma sp. ind. ex aff. biplex* Waagen. Fragmentary cast; *a* ventral view, *b* lateral view, *c* front view.
„ 8. "*Dielasma*" *sp. ind. aff. uralicum* Krotow. Cast of a ventral valve; *a* ventral view, *b* lateral view, *c* front view.
„ 9. *Reticularia cf. inæquilateralis* Gemmellaro. Cast; *a* ventral view, *b* dorsal view, *c* lateral view, *d* front view.
„ 10. *Monopteria subansirica* Diener. Plaster-cast taken from the impression of a left valve.
„ 11. *Myalina sp. ind.* Plaster-cast taken from the impression of a right valve.
„ 12. *Loxonema sp. ind.* Cast, with fragments of the test adhering.
„ 13. *Pleurotomaria sp. ind. aff. punjabica* Waagen. Plaster-cast taken from an impression.
„ 14. *Bellerophon sp. ind.* Cast.
„ 15. *Fenestella sp. ind.* Impression of the polyzoarium.

ON THE OCCURRENCE OF *ELEPHAS ANTIQUUS (NAMADICUS)* IN THE GODÁVARI ALLUVIUM, WITH REMARKS ON THE SPECIES, ITS DISTRIBUTION AND THE AGE OF THE ASSOCIATED INDIAN DEPOSITS. BY GUY E. PILGRIM, B.SC., *Geological Survey of India.* (With Plates 9—13.)

Locality of the find.

IN February of last year, Mr. H. F. G. Beale, of the Public Works Department, informed the Geological Survey of the discovery of fossil bones at Nandúr Madméshwar (Lat. 20° 1′; Long. 74° 11′), which I was at once deputed to excavate. The locality is on the Godávari river and is about eight miles south of Niphád station on the G. I. P. Railway in the Nasik district of the Bombay Presidency.

The Godávari alluvium.

Great interest must attach to any discovery of fossil bones in the Godávari alluvium, as so few records of such exist. As compared with the alluvial deposits of the Narbada, which flows in a contrary direction, and enters the sea on the west coast of India, our knowledge of those of the Godávari is very limited, both as regards the fossil contents, and even as to the nature, thickness, and superficial extent of the alluvium itself. It may not therefore be out of place to touch upon these points in the course of this paper, as tending to throw some light upon the origin both of the Godávari and of the Narbada deposits.

Previous fossil discoveries in the Godávari alluvium.

That the fossil fauna of the Godávari beds is no less rich than that of other Indian river deposits, is proved by the reports we have in the past of exceptionally large "finds" of bones in them. In but few cases, however, has any trouble been taken to preserve the bones or turn the discovery to scientific account. At some time during the fifties, an elephant skull was found in the Godávari valley. No account of the discovery seems to have been published, and, so far as I know, the only authentic record of it is contained in a manuscript note by the late General Twemlow, the original discoverer. To this Dr. W. T. Blanford had access when he wrote his note on the Godávari gravels.[1] He considers that it is the same as

[1] Mem. Geol. Sur. Ind., VI, p. 232.

that referred to by Dr. Falconer in a paper read before the Geological Society of London,[1] when he mentioned the occurrence of *Elephas namadicus* "in richly fossiliferous fluviatile deposits of Southern India." Major-General Twemlow also seems to have been under the impression that the skull in question was examined and named by Dr. Falconer. We may therefore conclude that this Godávari elephant was identified by Falconer as *Elephas namadicus*, Falc. and Cautl. It was obtained from a place near Paitán, a town on the Upper Godávari, south of Aurangabád, (19° 45′; 75° 30′) on the left bank of the river, and had been washed out of a calcareous conglomerate, of which the bank consisted. The skull was sent to Sir Philip Egerton in England, but I have no knowledge of what eventually became of it. It appears to have been of immense size, as the tusk is said to have been 29 inches in circumference. The tusk of the animal which forms the subject of the present paper measures 25 inches in circumference at the base.

Ossiferous deposits of the Pem Ganga.

General Twemlow also met with very extensive deposits of mammalian bones in the valley of the Pem Ganga at Hingóli (19° 55′; 77° 2′), and is of opinion that these ossiferous gravels are widely spread throughout the valleys of the Godávari and the Pem Ganga.

In 1867 Mr. Fedden, of the Geological Survey of India, examined the whole area through which the Pem Ganga flows. He discovered a few bovine bones, but neither at Hingóli nor elsewhere did he come across any extensive fossil remains.

It appears from his observations that the gravels, though widely scattered, are not continuous, and while in some places they form the bed of the river, in others the Pem Ganga has cut down its channel into the Deccan Trap or even into the older crystalline rocks below.

The alluvial deposits at Nandur Madmeshwar.

Since 1867, however, no collections were made from these interesting deposits until February 1904. I shall therefore proceed to the details relating to this latest fossil find.

In the area which I was able to examine, most of the alluvial deposit lies on the left bank of the Godávari. The alluvial cliffs rise to a height of about 60 feet above the general level of the river-bed and are highest at a point about 1 mile farther up the river than Nandúr Madméshwar. It was here that I found, embedded in the

[1] Q. J. G. S., XXI, p. 381; Falconer Pal. Mem., II, p. 463.

gravels, in the very channel of the river, a magnificent skull of the ordinary Narbada elephant. These cliffs consist of conglomerates, gravels, and clays quite devoid of any stratification and showing evidences of a continuous period of deposition, marked only by such changes in the character of the deposit as might be expected in the history of most rivers. Calcareous concretions (*kankar*) were not observed in any portion of the deposit. The river-bed here was perhaps a quarter of a mile wide, but at the time of my visit most of it was entirely dry and the flow was kept up only in two or three channels. The broadest of these is shown in plate 9, and occupies the extreme right-hand margin of the river-bed. The falls shown are not more than 15 feet high, and are entirely of the Deccan Trap. In fact, all the rock within sight here is of the same nature, as is also the greater portion of the dry bed of the river. To the right of the river just here, there seems to be hardly any trace of alluvium, although lower down, opposite Nandúr Madméshwar, the right bank is alluvial. On the left of the river, however, the alluvial deposit stretches away some distance, but has been deeply carved out into innumerable small gullies showing to what an extent the forces of denudation have been acting. It would seem as if this alluvial deposit were confined to the immediate neighbourhood of the Godávari or of its main tributaries, one of which, the Kadva, I followed from the railway. At various places near its banks, the same network of deep channels had been cut out of the soft alluvial gravels, the existence of which I have noted on the Godàvari. The smaller tributaries, however, had cut down into the Deccan Trap, and in many cases their sides consisted only of trap and soil arising from disintegration of trap. One is therefore led to the conclusion that the alluvium, though distributed over a wide area and accumulated locally to a considerable thickness, does not persist equally, and, except in the immediate neighbourhood of the depositing streams, is either superficial or altogether absent. It seems highly probable, however, that the alluvium of the Godávari valley as a whole, even if it be only superficial, is sufficient to merit a recognition on the geological map as distinct as that which has been accorded to the more northern rivers.

Extent of the Godavari alluvium.

Immediately at the foot of the alluvial cliff above mentioned, the river flowed in three small adjacent channels, in one of which were the fossil remains. These channels were separated from one another by a

Situation and excavation of the Elephant remains.

by Falconer in the *Antiqua Fauna Sivalensis*, Plates 12A, 12B, figs. 1-3, and Plate 24A, figs. 4, 4*a*, as *Elephas namadicus*. These are the two most complete crania which have been known up to now, and are preserved in the British Museum. One of them has small tusks and probably belonged to an adult female. The tusk sheaths are broken off almost immediately in front of the nasal foramen. The other, that of a young male, has large tusks, and shows also the characteristic divergence of the incisive alveoli. Five other crania exist in the Geological Museum at Calcutta. These are all exceedingly imperfect. Two of them, however, show the supra-orbital ridge, which, until Pohlig's extensive discoveries of *E. melitensis*, Falc., in the Grotto di Pontale von Carini in Sicily,[1] had been considered peculiar to the Indian species, if indeed there were not still some Palæontologists left, who favoured Professor Leith Adam's surmise that this peculiar frontal projection was a deformity or a distortion produced by compression after death. The present skull is that of a fully grown male.

It seems that the supra-orbital ridge grew forward with age, so that in young skulls there is a considerable interval between its margin and the extreme tip of the nasal process; in the large female skull in the British Museum this interval is sensibly diminished, while in this latest specimen, which represents the largest and presumably the most aged type with which we are acquainted, the supra-orbital ridge almost overhangs the nasal fossa, and the interval is reduced to its smallest dimensions.

Craniological material of the European varieties of *E. antiquus*.

The craniological material of *Elephas antiquus* (stem. sp.), though fairly extensive, is very imperfect. A comprehensive account of it is given by Pohlig[2] in his masterly monograph on *E. antiquus*.

The two most complete fragments are preserved, the one in Heidelberg which has been figured by Pohlig,[3] and the other in Florence photographed by Weithofer.[4] Nothing is present in these beyond the intermaxillaries and the basal portion of the cranium including the maxillæ and the basioccipitals.

The other varieties of *Elephas antiquus* are included under the

[1] Abh. d. k. Bayer. Akad., XVIII, p. 75.
[2] Act. Acad. C. L. C. G. Nat. Cur. LVII, 1892, p. 337, &c.
[3] id. Taf. B. figs. 5, 5*a*, p. 276.
[4] Beitr. z. Pal. Ost. Ung. Bd. VIII., 1891, Taf. II, fig. 2 & Taf. III, fig. 1.

various pygmy types found in Sicily, Malta, Crete and Cyprus, and described by their authors under the names *E. melitensis* Falc.,[1] *E. Falconeri* Busk,[2] *E. mnaidriensis* Leith Adams,[3] and *E. cypriotes* Bate.[4]

Comparison between the teeth of the races of *E. antiquus*.

Considering only the teeth and mandible of *E. antiquus* and of *E. namadicus*, Leith Adams[5] remarked that they seemed to him to be indistinguishable. This opinion of Leith Adams has been endorsed by many subsequent writers, among whom I need only mention Naumann, Weithofer, Pohlig and Lydekker.

There are three varieties of molars observable in *Elephas antiquus* :—

1. The broad-crowned variety with closely packed, faintly crenulated ridges with no definite angulations or central expansions. This is the usual type of molar found in *E. namadicus.*

2. The narrow-crowned variety with a central expansion of the enamel discs, annulation, and well-marked crenulation in the ridges.

3. A thick-plated variety presenting intermediate characters. This type is represented by the *Elephas priscus* of Goldfuss, and it often closely approaches the lozenge-shaped disc of *E. africanus.*

These same three varieties of molar are present in the dwarf Maltese fossil Elephants.

Comparison between the crania of the races of *E. antiquus*.

For a long time the similarity of the dentition of the pygmy Elephants to that of *E. antiquus* has caused many Palæontologists to class them as mere varieties of the latter, although no complete crania of either existed. It would seem to have been assumed by Lydekker and others that the crania, when found, would be of a different type to the Indian form and would possess no supraorbital ridge. So far is this from being the case, however, that all the skulls of the dwarf forms which Pohlig[6] has figured from the Grotto di Pontale von Carini in Sicily bear a striking resemblance to *Elephas namadicus,* and leave us no excuse for

[1] Parthenon 1862, p. 780, & Falconer Pal. Mem. II, p. 298.
[2] Trans. Zool. Soc., VI, 1867, p. 251.
[3] Trans. Zool. Soc., IX, 1874, pp. 112, 116.
[4] Proc. R. Soc., LXXI, 1903, p. 498, & Ann. Mag. of Nat. Hist., Vol. XIV, 1904, p. 162.
[5] Leith Adams, Br. Foss. Elephants, p. 67, 56.
[6] Abh. d. k. Bay. Akad. XVIII, p. 75.

separating the two forms specifically. The accompanying text-figure, taken from one of Pohlig's plates, brings out these resemblances in a remarkable degree. There is no doubt that future discoveries will prove that the original *E. antiquus* of Europe possesses the same craniological peculiarities as its Indian variety.

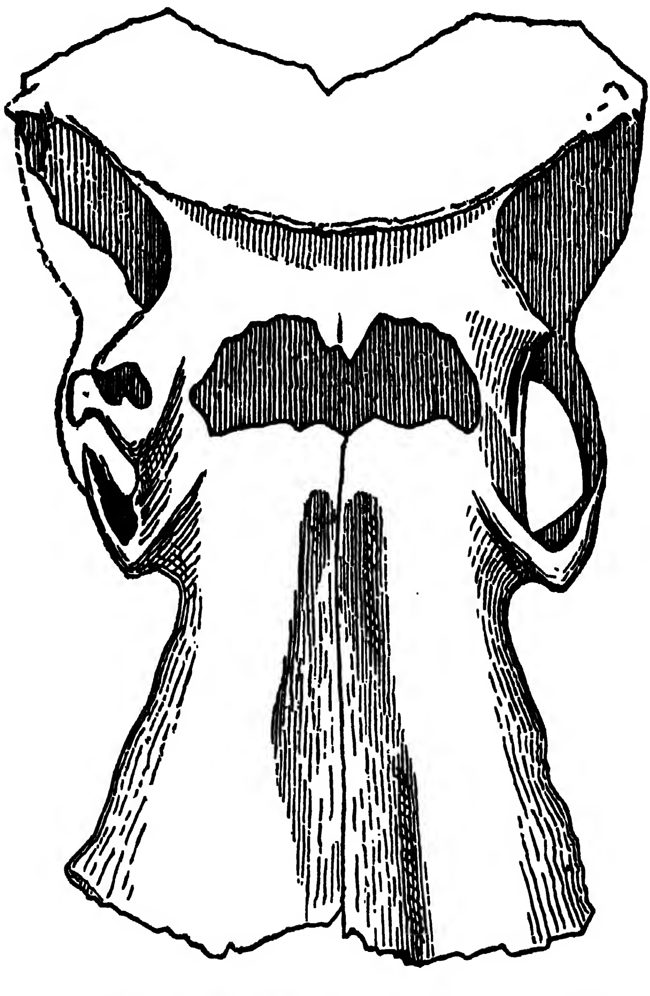


FIG. 1.—*E. antiquus* (*melitensis*) Falc. after Pohlig. [Fossile Elephantten aus Sicilien, Abh. d. k. Bay. Akad. XVIII. Taf. I, fig. 1.].

The crania of *E. antiquus* (stem. sp.), imperfect as they are, show the following points in common with the Indian variety and the pygmy types which serve to distinguish them from all other elephants:—

1. The extreme divergence of the incisive alveoli and the broad shallow depression which occupies their centre.

2. The great distance of the occipital fossa from the foramen magnum and the basal breadth and extreme depth of the fossa.

3. The strong convexity of the occiput in a horizontal direction, which pushes the zygomatic process of the temporal to the front in an unusual degree.

The crania of the Sicilian and of the Narbada elephants exhibit in addition the following points of likeness:—

4. The shortness and breadth of the brow and the widening out of the cranium from below upward.

5. The rhomboidal outline of the temporal fossa and its sharply-cut, acute-angled upper margin.

6. The presence of protuberances on either side of the occipital fossa.

7. The almost rectangular bend by which the occipital passes into the parietal, and the obtusely-angled junction between the parietal and frontal surfaces.

8. The well-marked frontal projection of the crown, which must have given an exceedingly beetling aspect to the living animal.

9. The approximately transversely oval contour of the cranium, when viewed in a direction at right angles to the plane of the occiput. It is much broader than high.

E. africanus also approaches them to some extent in regard to the 1st, 4th, 5th and 9th of the above characters. This is quite in accordance with the view that *E. africanus* is the living representative of an old ancestral form from which it took its origin along with *E. planifrons* Falc. & Cautl, *E. antiquus*, and possibly *E. meridionalis* Nesti. Pohlig[1] remarks that he can hardly recognize any essential differences between the portions of the cranium of *E. antiquus* (stem. sp.) known up to now and the London crania of *E. namadicus*. He calls attention to the differences in the molars and to the greater absolute dimensions of *E. antiquus* (stem. sp.). But as has been explained above, with the exception of the generally higher ridge formula, which prevails in the Indian variety, the molars of the latter are indistinguishable from the broad-crowned type of *E. antiquus*, while the present remains show that the advantages in point of size by no means lay with the European form. Pohlig considers that the suborbital foramen is larger and shorter in *E. namadicus*; that the occipital condyles do not attain such a colossal size; that the maxillary

[1] Act. Acad. C. L. C. G. Nat. Cur., LVII, p. 353.

zygomatic process lies somewhat higher; and that the profile line of the occiput appears to have formed a less obtuse angle with the extension of the sphenoidal portion. The importance of the last of these is, however, discounted by the equally obtuse angle exhibited in the corresponding region of the present cranium. In addition to this and the already mentioned excessive forward growth of the frontal ridge, the present cranium differs from the hitherto described crania of *E. namadicus* in the following particulars:—

The depth of the intermaxillary sinus at its proximal end is rather greater, and would seem to resemble the specimen of *E. antiquus* (*melitensis*) figured by Pohlig.[1]

As far as I can judge, the protuberances on either side of the occipital fossa are by no means so prominent as in the London cranium of *E. namadicus*, nor are the corresponding external depressions so marked.

The occipital fossa is extremely wide below and narrows to an unusual extent above, bearing some resemblance to a cranium from the Narbada described by Falconer.[2] The occiput itself is also exceptionally wide.

Below is a table giving the actual dimensions of the present cranium and of the London cranium figured in the Antiqua Fauna Sivalensis plates 12A, 12B, along with those of the Florence cranium of *E. antiquus* (stem sp.) and of the Palermo cranium of *E. antiquus* (*melitensis*).

Measurements of Crania in inches.

	E. ANTIQUUS (NAMADICUS).		E. antiquus (stem sp.) Florence.	E. antiquus (melitensis) Palermo.
	Calcutta.	London.		
Maximum length from occipital to tip of premaxillaries.	55·0	...	63·0	...
Maximum breadth at widest part of occiput.	42·4	30·0	...	19·7
Vertical height from occipital condyles to vertical plane.	23·7	15·5	...	...
Width of brow between temporal fossae at narrowest part.	27·4	20·0	...	10·2
Width of brow between centre of orbits .	25·0	20·0	...	...

[1] Abh. d. k. Bay. Akad. XVIII, plate III, fig. 2.

[2] Falconer, Pal. Mem. I, p. 115.

	E. ANTIQUUS (NAMADICUS).		E. antiquus (stem sp.) Florence.	E. antiquus (melitensis) Palermo.
	Calcutta.	London.		
Width between postorbital processes .	32·0	25·0	...	...
Vertical distance between plane of vertex and tip of nasal process.	11·5	8·2	...	3·5
Transverse extent of nasal opening .	20·0	15·0	...	...
Vertical height of nasal opening at sides.	5·6	5·3	...	...
Distance from anterior margin of nasal opening to tip of premaxillaries.	34·0	...	...	13·4
Distance from vertex to tip of premaxillaries.	50 +	...	...	...
Maximum width of premaxillaries at the distal end.	36·2	...	37·0	...
Maximum width of premaxillaries at orbital foramen.	19·8	...	18·9	..
Width of intermaxillary fossa at proximal end.	4·1	5·8	...	...
Width of intermaxillary fossa at distal end.	13·2	...	...	...
Vertical diameter of orbit . . .	9·5	6·2	...	...
Transverse diameter of orbit . .	5·0	...	...	...
Depth of occipital fossa from plane of vertical bosses.	12·5	7·5	...	...
Maximum width of occipital fossa below.	8·5	5·6	...	...
Minimum width of occipital fossa above.	3·1	4·8	...	...
From external auditory meatus to frontal margin of fossa at contraction.	15·7	13·3	...	...
From external auditory meatus to anterior margin of orbit.	17·5	14·0	...	...
From posterior plane of occiput to tips of nasals.	27·0	17·4	...	...
From posterior plane of occiput to anterior margin of orbit.	26·5	22·2	...	...
Width between margin of nasal opening and margin of orbit.	5·0	3·7	...	...
Width between margin of nasal opening and adjoining portion of temporal fossa.	4·5	4·1	...	...
Maximum diameter of tusk near origin .	8·0	...	...	...
Maximum circumference of tusk near origin.	25·0	...	...	..

Allied species.

E. antiquus may be classed with the short-crowned elephants, *E. africanus* Blum., *E. planifrons* Falc. et Cautl., and *E. meridionalis* Nesti. Corresponding with this character is the ratio between the length from the vertex to the extremity of the premaxillaries and the breadth of the cranium between the post-orbital processes.

E. africanus.

E. antiquus approaches nearest to *E. africanus* in the flattened shape of the vertex, in the shortness and breadth of brow, in the form of the temporal fossa and of the interjugal space, and in the obtusely angled junction between the frontal and occipital surfaces. It differs in the slope of the occipital surface, in the greater length and shallowness of the intermaxillary median fossa, in the convexity of the occiput, in the higher position of the maxillary zygomatic process, and in the shorter length and greater width of the sub-orbital foramen.

E. planifrons.

E. planifrons differs from *E. antiquus* in the extreme lowness of the vertex and of the occiput, the lower position of the maxillary zygomatic process, the extremely small dimensions of the nasal aperture, the excessive length and narrowness of the sub-orbital foramen, and in the small width and great depth of the intermaxillary fossa; this species stands, however, in a closer relation to *E. africanus*.

E. meridionalis.

E. meridionalis, though possessing the deep and large occipital fossa of *E. antiquus* and an excessive development of the occipital protuberances, differs essentially in the extreme narrowness and great concavity of the frontal region, in the trifling divergence of the incisive sheaths, the deeper intermaxillary fossa, in the narrowness and length of the sub-orbital foramen, and in the long and pointed shape of the temporal fossa.

It seems probable that all these species were developed from a common ancestor in a great Indo-Africo-European province in eocene or oligocene times and the subsequent disconnection, or partial disconnection, of these areas led to the differentiation of the individual types.

Improbability of the descent of *E. indicus* from *E. antiquus*.

Although there is no impossibility in the teeth of *E. indicus* Linn., being derived from those of *E. antiquus* (*namadicus*), the teeth of the former being of a more advanced type in the same direction, yet Mr. Lydekker[1] considers that such a descent would be most improbable, with which opinion I concur. Considering the long, high, narrow cranium of *E. indicus* Linn., with its pointed, concave vertex, it is inconceivable that the one form should have been derived from the other within the short period which we know to have elapsed between the latest remains of *E. antiquus* (*namadicus*) and the present day.

Description of the pelvis.

The pelvis.—The portions of the hip bones which I was fortunate enough to obtain are the following. That part of the pelvis lying between the two acetabula is complete with the exception of the lower part of the pubic symphysis; the bones are, however, fractured in various places. Of the two ossa innominata the left one is the better preserved. In it the acetabulum is perfect and is united to the internal region of the ilium; the external part of the latter is, however, missing. The ischium is broken off between the acetabulum and its own ascending ramus, so that the obturator foramen is incomplete. Of the right os innominatum only portions of the acetabulum and of the ilium are preserved besides the pubis as mentioned above. The central portions of the innominate bones across the pubic symphysis are figured in plate 13, fig. 1, and the upper part of the left ilium with its sacral margin in plate 13, fig. 2. These show the total width of the pelvic opening as well as the superior half of the obturator foramen. The remaining fragments have not been photographed.

The following are the measurements of the pelvis in inches :—

Distance between the inner margins of the two acetabula .	19·0 in.
Antero-posterior diameter of acetabulum	8·5 ,,
Transverse diameter of acetabulum	8·3 ,,
Breadth of pelvic opening	21·6 ,,
Breadth of obturator foramen	5·6 ,,
Girth of pubis at midshaft	13·0 ,,

It will be seen that, contrary to what is the case in the Indian elephant, the antero-posterior measurement of the acetabulum is slightly greater than the transverse one. The cotyloid fossa is narrower than in the recent species, and opens directly on to the outer border of the obturator foramen and not on to a flat surface.

[1] Pal. Ind., ser. X, Vol. I, p. 289.

Description of the femur.

The femur.—Both ends of the femur and a great portion of the shaft are in our possession. These are shown in Plate 13, figs. 3 and 4. The distal portion has been photographed end on, and the proximal portion lengthwise. It appears to be very similar both to those assigned to *E. namadicus* already in the Indian Museum, as well as to the one of *E. antiquus* figured by Leith Adams (Br. Foss. Elephants, Pl. XXII, fig. 5). The bone is long and slight. The patellar surface is broad and shallow. The intercondyloid space is not great. The neck is short and appears to be almost erect with very little inclination. The digital pit is shallow. The head seems to be rather oblique. The following are the measurements of the femur, the total length of which is estimated as having been about 69 inches:—

Length of fragment of femur from distal end to fragmented margin	40·0 in.
Length of fragment of femur from proximal end to fragmented margin	19·0 "
From distal end to narrowest portion . . .	35·0 "
Maximum circumference of distal extremity around the tuberosities	34·0 "
Maximum diameter of distal extremity around the tuberosities	12·0 "
Minimum circumference of femur	20·5 "
Breadth of proximal end at great trochanter . .	19·0 "
Girth of ball of head	25·0 "

Restoration of the cranium.

I shall now add some brief explanations in reference to the mounting of the cranium and the photographs which have been taken of it, in connection with which I wish to acknowledge the assistance and the many useful suggestions which my colleagues Mr. E. Vredenburg and Mr. H. H. Hayden have kindly given me in the course of the erection and reconstruction of the specimen. The cranium, with certain plaster additions to it, stands in the vertebrate gallery of the Geological Museum, Calcutta, on a firm iron support, and the remaining bones of the skeleton are arranged near it. It was not deemed advisable to attempt any other restoration than that which was necessary to show the relation of the broken fragments to the main part of the cranium, and as to the correctness of which there could be no doubt. The tusks represented in the plates do not consist in any part of the original tusk, but are copied therefrom out of wood. In this way a more secure support has been obtained on which the pieces of bone and plaster are fastened. The white colour of the plaster in the plates shows sufficiently well how much of the specimen is restoration. It must however be remarked that in the course of transport as well as during the erection many losses and breakages have occurred. On this account an inspection of the plate may perhaps produce the impression that the information at my disposal for the restoration was less precise than is really the case; not only were the junctions between the fragments much more clearly defined originally, but also while clearing away the matrix the position of the parts was more apparent than it is at present. The photograph of the cranium in front view reproduced in Plate 11 was taken by Mr. E. Vredenburg with a telescopic lens at a distance of 18 yards, so as to prevent any distortion in the picture. As this method was impossible in the case of the side view owing to the position of the cranium in the Museum, Plate 12 was drawn in cylindrical projection, and as the orbital portion is much better preserved on the left side, this has been combined in the drawing with the remainder of the right-hand side of the cranium. Plate 10 represents a view of the cranium from the left before the restoration.

Contemporaneity of the Godavari and Narbada ossiferous deposits.

The question of the age of these deposits containing *E. antiquus* (*namadicus*) now demands some consideration. Comparing the fauna of the Godávari alluvium with that of the older Narbada deposits, we shall see that the only three mammalian species found in it up to now are identical with Narbada forms. Of these *E. antiquus* (*namadicus*) Falc. et Caut., and *Hippopotamus palæindicus* F. et C., are quite absent from the older deposits of the Siwalik beds, while *Equus namadicus* F. and C. comes up from below. We are therefore justified in regarding the two series of alluvia as of approximately the same age, and any conclusion we arrive at with respect to the Narbada deposits must apply equally to those of the Godávari. We must also extend this statement to include a great portion of the older Gangetic deposits, where in the valleys of the Jamna and Ganges near Allahabad have been found the following:—[1]

Semnopithecus sp.	*Sus* sp.
Elephas namadicus F. and C.	*Cervus* sp.
Mus sp.	*Bubalus palæindicus* F.
Hippopotamus palæindicus F. and C.	*Bos namadicus* F.
Equus sp.	*Antilope* sp.

[1] Q. J. G. S. XXI, p. 377; Falconer Pal. Mem., II, p. 640, and Rec. Geol. Surv. Ind., XXXI, p. 176.

The following is a list of the Narbada vertebrate fauna, which has hitherto been identified:—

The Narbada fauna.

Ursus namadicus F. and C.	*H. namadicus* F. and C.
Bubalus palæindicus F.	*Equus namadicus* F. and C.
Leptobos fraseri Rut.	*Rhinoceros unicornis* Linn.
Bos namadicus F.	*Elephas namadicus* F. and C.
Cervus duvaucelli Cuv.	*E. insignis* F. and C.
Sus sp.	*E. ganesa* F. and C.

Hippopotamus palæindicus F. and C.
Pangsura tectum Bell, and other reptilia.

Age of the Narbada ossiferous alluvium.

It will be remembered that Dr. Falconer designated these beds as pliocene at the same time as he concluded that the typical Siwaliks of the outer Himálayas, now classed as middle and upper Siwaliks, were miocene. The arguments for the pliocene age of the latter have been stated in the Manual of the Geology of India,[1] and are based on—

1. Their stratigraphical relation to the Mánchhar beds of Sind. The position of the latter immediately above the Gáj beds containing marine strata of miocene age, fixes their age as not older than the upper miocene. The beds of the original Siwalik area must therefore be pliocene.

2. The general facies of the fauna as compared with recent types and with the mammalian beds of the Mánchhars and Baluchistan; the latter have a distinctly older aspect.

Moreover, the immense thickness which has actually been proved for these middle and upper Siwaliks is evidence of a prolonged period of deposition; and the frequently observed occurrence of older as well as of more recent types confined to definite disconnected areas or to demonstrably different horizons in the series renders it probable that a very long period was required for the differentiation of such a diverse fauna. The Mánchhars as well as the ossiferous beds of Baluchistan are now classed with the Siwaliks, and the strong relationship which their fauna bears to that of the Pikermi and Samos deposits is quite recognized. Dr. W. T. Blanford, Mr. R. Lydekker and others class these beds in the lower pliocene,[2] which gives us a still

[1] Man. Geol. Ind., 1st. ed., ch. XXIV; 2nd ed., ch. XIV.

[2] Blanford, address to Br. Ass., 1884; Lydekker, Geog. Hist. of Mammals, 1896, p. 197; Geikie, Text book of Geol. II, p. 1296, 4th ed., 1904.

newer age for the middle and upper Siwaliks referred to above. Mr. Lydekker[1] in 1883 gave it as his opinion that the topmost beds of the Siwaliks, containing the newer types, *Camelus sivalensis*, *Bubalus palæindicus* and *Equus namadicus*, were probably upper pliocene or even pleistocene; his latest classification does not tend to invalidate this view.

The unconformity between the older alluvial deposits of the plain and the Siwaliks has been generally admitted[2]; the alluvial strata are nowhere inclined, and the deposit must in all cases have taken place subsequently to the great earth movements, which resulted in the upheaval of the outer Himálayas. These peninsular deposits must therefore be put at any rate into the pleistocene, and since the deposition could not have been continuous with that of the Siwaliks, there may be a considerable time break between the two series.

So much for stratigraphical evidence. The fossil molluscan fauna[3] of these beds does not contain any species, which is not identical with those at present living in the same area, although many species now living have not been found, while the relative proportion which the individual species bear to one another is different from that which prevails at the present day. As regards the vertebrate fauna there is no single genus which does not exist at the present day, although *Elephas* and *Hippopotamus* are in part represented by subgenera, which are now extinct. *Rhinoceros unicornis* is identical with the living species, while *Bubalus palæindicus* and *Cervus duvaucelli* are nearly allied respectively to the modern Indian buffalo and the barasingha. *Pangsura tectum* and possibly others of the *Reptilia* are also identical with forms which frequent the Indian rivers of to-day. *Elephas insignis*, *Elephas ganesa* and *Equus namadicus* have come up from the Siwaliks, and *Hippopotamus namadicus* may have originated from a Siwalik ancestor; *Hippopotamus palæindicus* belongs to a subgenus now only found in Africa. *Elephas namadicus* is identical with the European *E. antiquus*, while the phylogeny of *Ursus namadicus*, *Bos namadicus* and *Leptobos frazeri* is obscure. A fauna

[1] Pal. Ind., X, II, 96.

[2] Mr. Medlicott (Rec. G. S. I., VI, pt. 3, p. 52) states that the older alluvial clay of the Ganges rests on the denuded upturned surface of the upper Siwaliks at Hardwar. The topmost beds containing *Bubalus* and *Camelus* mentioned in the text are inclined, according to Falconer, at an angle of 20°, while at Bubhor strata with the same fossils are vertical (Rec. G. S. I., IX, p. 57).

[3] Mem. G. S. I., II, p. 284.

of such a type and with such recent affinities shows no inherent likelihood of having lived at a time approximating very closely to that of the Siwaliks, and we cannot reasonably assign to it a date earlier than pleistocene.

Geographical and geological distribution of *Elephas antiquus*.

In conclusion, it may be of interest to review briefly the various regions where remains of *Elephas antiquus* are found along with the geological horizons through which they are distributed. The case of *Elephas antiquus* is of special interest as it is a species which, by virtue of its powers of locomotion and its adaptability to varying environments, had a very wide geographical distribution and has been recorded from deposits ranging through a very considerable period.

India.

In the first place we have to notice that it is entirely absent from all the Siwalik strata, nor, as we have seen, is there any ancestral Siwalik type from which it might claim immediate descent. But as soon as we begin to examine the younger deposits of the Godávari, the Narbada and the Ganges, we at once find its remains in abundance.

Burma, China, and Java.

It has also been found in Burma,[1] China and Java, though *sparingly* so as compared with many other mammalia, which the researches of Owen,[2] Martin,[3] Koken[4] and Schlosser[5] have disclosed to us in the same countries.

Japan.

Naumann[6] has also recorded a tooth of *E. antiquus* from Japan. All these deposits are considered to be of younger date than those of Siwalik age.

Europe.

On the other hand *E. antiquus* is found widely distributed in the upper pliocene of Europe. It was essentially a southern type and its remains are found most

[1] Lydekker, Cat. Pleist. Vert. Ind. Mus., 1886, p. 14, and Foss. Mam., IV, p. 168.

[2] Owen, Fossil remains of Mammals found in China, Q. J. G. S., XXVI, 1870, p. 417.

[3] Martin, Fossile Saugethierreste von Java und Japan, Samm. d. Geol. Reichs. Mus., Lei. IV, 1886, 25.

[4] Koken, Ueber fossile Saugethiere aus China. Pal. Abhandl., III, 1886, 31.

[5] Schlosser, Die fossilen Saugethiere Chinas. Abhandl. d. k. Bay. Akad., XXII, 1903, p. 1.

[6] Palæontographica, XXVIII, 1881, p. 25, Taf. 6 and 7.

abundantly in Italy. Thence it extended both to northern Africa, which in upper pliocene times or later was united to the mainland of Europe, to England[1] and to Germany. It attains its maximum in the pleistocene deposits of the same countries, mingling with northern species, perhaps in the course of seasonal migrations according to the views expressed by Prof. Boyd Dawkins.[2]

Distribution of the stem species of *E. antiquus*.

The four dwarf races of *E. antiquus* are confined to four isolated areas centred respectively in the islands of Sicily, Malta, Crete and Cyprus. One can therefore hardly avoid the conclusion that the dwarfing of the type was due to its insulation in these areas under similar conditions of overcrowding and starvation. It may be remarked that additional evidence for this belief is afforded by the presence of pygmy species of Hippopotamus, *H. pentlandi* Meyer and *H. minutus* Blainv. in Sicily, Sardinia and Cyprus. These are both nearly allied to *H. major*, the large continental species. In Sicily Pohlig has also described a small race of red deer, which he considers indistinguishable from *Cervus elaphus* Linn., except in point of size. That the conditions of existence were somewhat abnormal is perhaps indicated by the presence of a gigantic dormouse, *Myoxus melitensis* Leith Adams. Remains of these animals Pohlig found in Sicily mingled with typical Pleistocene forms, *Bos primigenius* Boj., *Bison priscus* Boj. and *Hyæna spelæa* Gold. It seems likely therefore that the severance of these islands from the mainland, which resulted in the differentiation of this peculiar fauna, took place in early pleistocene times.

Distribution and origin of the dwarf races of *E. antiquus*.

The geographical and geological distribution of *Elephas antiquus* outlined above, suggests the probability that this is a species which originated in Europe and migrated thence to India and the Oriental regions.

Suggestions on the origin of the Indian variety of *E. antiquus*.

It may be that the causes to which we can ascribe such a migration are to be found in the increasing cold of the glacial period in Europe, and in the closure of a line of retreat southward into Africa.

[1] Remains of *E. antiquus* are found in the Norwich Crag, which is probably older than the topmost Siwaliks; according to Leith Adams molars of the species were obtained from the Red Crag.

[2] Q. J. G. S., XXVIII, p. 428, etc.

It may possibly be worth considering whether a similar migratory theory may not explain the resemblances of the later pleistocene and recent faunæ of India, to those of pleistocene Europe, and of Africa of the present day. Be that as it may, however, *E. antiquus* seems to have lived on in India long after its relatives had perished on the continent of Europe; still here too it died out, leaving no descendants to carry down its special characteristics to posterity, for, as we have seen, the present Indian elephant cannot claim kinship with it.

Summary.

The points to which special attention has been invited in this paper may be shortly summed up as follows:—

1. That the Godávari alluvial deposits are of approximately the same age as those of the Narbada.

2. That they must be considered as not *earlier* than lower pleistocene.

3. That their distribution is wider than would be inferred from the geological map.

4. That through the researches of Prof. Pohlig and others we have definite proof that the Narbada elephant is only a variety of *Elephas antiquus*.

5. That the distribution of *Elephas antiquus* strongly suggests a European origin for the species.

THE TRIASSIC FAUNA OF THE TROPITES-LIMESTONE OF BYANS. BY PROF. C. DIENER, PH.D., *of the Vienna University.*

IN Byans cephalopoda of upper Triassic age have been collected by C. L. Griesbach in a grey limestone in the upper valley of the Kali river near Kalapani. The credit for their correct interpretation is due to E. v. Mojsisovics, who was able to determine a small number of forms agreeing with, or very nearly allied to, species of the Alpine *Subbullatus*-beds of the upper carnic stage.[1]

A full description of the meagre fauna of the Tropites-limestone of Kalapani has been given by E. v. Mojsisovics in *Denkschriften Kais. Akad. d. Wissenschaften, Wien,* 1905, Bd. LXIII, and in the 3rd volume of "Himálayan Fossils" (*Palæontologia Indica,* ser. XV). Although the fossils were too badly preserved to permit a specific determination, the carnic type of the faunula showed itself so clearly in the association of genera, that he did not hesitate in correlating it with the fauna of the Alpine zone of *Tropites subbullatus.*

The genus *Tropites* being the chief leading fossil of this horizon, the name Tropites-limestone has been given and accepted generally in Indian literature.

Equivalents of the zone of *Tropites subbullatus* were not found in the sections closely examined by C. L. Griesbach, C. S. Middlemiss, and myself in 1892. Therefore, it seemed most desirable that the fossiliferous localities in Byans should be revisited and that larger collections of fossils should be made in the Tropites-limestone. Geological researches were made in Byans by F. H. Smith in the summer of 1899 and by A. v. Krafft in 1900, and large collections of cephalopoda from the Tropites-limestone were obtained from the following localities: Lilinthi, Tera Gádh, Kalapani on the Kali river, Nihal and Kuti on the Kuti Yangti river.

The following is a section through the lower, middle and part

[1] *E. v. Mojsisovics,* Vorlaeufige Bemerkungen ueber die Cephalopodenfaunen der Himalaya-Trias. Sitzgsber. kais. Akad. d. Wiss., Cl. 1. Abt., Mai 1892.

of the upper Trias, as observed in Byans by F. H. Smith and A. v. Krafft:

Noric stage .	3. Black shales . .	1,000 feet
Carnic stage .	2. Massive limestone . . Near top, *Tropites*, etc.	250 „
Ladinic „ .	70 feet above base, cephalopoda of upper Muschelkalk; immediately below, brachiopoda of the zone of *Spiriferina Stracheyi*.	
Muschelkalk .		
Lower Trias .	1. Chocolate limestone . .	150 „

According to A. v. Krafft, the fossiliferous horizon with *Tropites* is invariably found at the top of the massive grey limestone, which in its lower portion has yielded cephalopoda (*Gymnites Jollyanus*) and brachiopoda of the muschelkalk. The Tropites-limestone, occurring near the base of the black shales of noric age, does not exceed three feet in thickness and is the only upper Triassic horizon of Byans rich in ammonites, whereas all the other beds are practically unfossiliferous.

The beautiful materials collected by Smith and A. v. Krafft have been entrusted to me for examination by the Director of the Geological Survey of India. The full description of the fauna of the Tropites-limestone will form the first part of Vol. V of "Himálayan Fossils" (*Palæontologia Indica*, ser. XV). Although the manuscript has been finished and sent to Calcutta, considerable time must elapse before its publication. The remarkable interest connected with the results of my examination induces me, however, to give this short preliminary notice.

There are, altogether, 168 forms known to me from the Tropites-limestone of Byans, 155 species belonging to the order of *Ammonoidea*. The fauna of this horizon is therefore one of the richest Triassic faunas hitherto known. Its most characteristic feature consists in the overwhelming predominance of cephalopoda.

Among 155 species of ammonites 104 are peculiar to the Tropites-limestone of Byans, 51 are identical or probably identical with species from the Triassic Hallstatt-limestone of the Eastern Alps, or from the upper Triassic Halorites-limestone of the Himálayas. But among the new species the number of forms very nearly allied to European ones is much larger than the number of types which impart to the Indian Triassic province the character of a zoogeographical region of its own.

As faunistic elements peculiar to the Tropites-limestone of Byans, but unknown in the Mediterranean region, the following may be considered: *Trachypleuraspidites*, a sub-genus of *Dittmarites*, with remarkable morphological affinities to *Trachyceras*; the sub-genus *Himavatites*, in which characters of *Acanthinites*, *Sagenites* and *Trachyceras* have been united; the strange genus *Jellinekites* with three external keels, which are repeatedly interrupted by transitional constrictions; the group of *Sirenites Vredenburgi*, distinguished from other congeneric species by its very delicate sculpture, thin, thread-like ribs and transversely elongated tubercles; the groups of *Drepanites Schucherti* and of *Clionites gracilis*, differing considerably from all congeneric forms of the Alpine region; the groups of *Tropiceltites arietitoides*, imitating liassic *Arietidæ* in its external characters, and of *Distichites ectolcitiformis*, a transitional shape between the two genera *Distichites* and *Ectolcites*.

The relations with upper Triassic faunæ of the Mediterranean region are most clearly indicated by the occurrence of numerous identical or closely allied forms in the two areas. But the assemblage of those species in the Tropites-limestone of Byans is very peculiar, and exhibits rather conflicting characters.

In Griesbach's small collection ten species of ammonites were noticed by E. v. Mojsisovics, all of them pointing to a correlation with the carnic stage of the Hallstatt limestone, especially with the zone of *Tropites subbullatus* (tuvalic sub-stage). In the rich materials collected by Smith and A. v. Krafft the *carnic* type of the fauna shows itself in the assemblage of the following genera: *Thisbites*, *Arpadites*, *Trachyceras*, *Protrachyceras*, *Jovites*, *Gonionotites*, *Eutomoceras*, *Anatropites*, *Carnites*, *Proarcestes*, *Pararcestes*, *Lobites*. There are altogether 27 species identical or probably identical with species of the carnic stage of the Salzkammergut. Among them 16 belong to the tuvalic, 8 to the julic sub-stage, 3 are common to both sub-stages. The majority of faunistic elements consequently points to the zone of *Tropites subbullatus*. Especially those groups of carnic elements, which give to the fauna its peculiar type and are conspicuous for their specific fecundity—*Tropites*, *Margarites*, *Anatomites*—are leading fossils of the tuvalic sub-stage of the Hallstatt limestone.

The species of ammonites bearing the stamp of a tuvalic age are contained in the following list:—

Tropites subbullatus v. Hauer.
„ *cf. fusobullatus* Mojs.
„ *cf. discobullatus* Mojs.
„ *cf. Estellæ* Mojs.
„ *cf. Paracelsi* Mojs.
Margarites Georgii Mojs.
„ *cf. auctus* Dittm.
Polycyclus Henseli Oppel.
Sandlingites cf. Oribasus Dittm.
Sirenites Pamphagus Dittm.
„ *Agriodus* Dittm.
Anasirenites cf. Menelaus Mojs.
Anatomites cf. Edgari Mojs.
„ *cf. Thedori* Mojs.
„ *cf. crasseplicatus* Mojs.
Arcestes bicornis Hauer.

The following species of the Tropites-limestone of Byans are leading fossils of the zone of *Trachyceras Aonoides* (julic sub-stage) in Europe:—

Arpadites Tassilo Mojs.
Isculites Heimi Mojs.
Anatomites cf. Fischeri Mojs.
Tropites Wodani Mojs.
Carnites cf. floridus Wulf.
Proarcestes Gaytani Klipst.
Pararcestes cf. Sturi Mojs.
Lobites cf. ellipticus Hauer.

Protrachyceras is represented by two, *Trachyceras* by one species. In Europe these two genera mak^ their appearance for the last time in the julic sub-stage, but have been found in the Tropites beds of California of undoubted tuvalic age by J. Perrin Smith (*Amer. Journ. Geol.*, II, p. 607, III, p. 377).

Three species of the Tropites-limestone, *Pinacoceras cf. rex* Mojs., *Eutomoceras sandlingense* Hau., *Margarites cf. circumspinatus* Mojs., are common to the julic and tuvalic sub-stages.

From this proportion of julic and tuvalic elements in the Tropites-limestone it is evident, that a greater number of relationships and analogies speaks in favou of a correlation with the tuvalic sub-stage.

There is, however, a second faunistic element equally distributed in the Tropites-limestone of Byans. This element consists of genera and species of ammonites characteristic of the *noric* stage of the Hallstatt limestone. The following species are identical with species from the noric stage of the Salzkammergut:—

Helictites cf. geniculatus Mojs.
" *cf. subgeniculatus* Mojs.
Phormedites fasciatus Mojs.
Parathisbites cf. Hyrtli Mojs.
" *cf. scaphitiformis* Hauer.
Distichites cf. Harpalos Dittm.
Sirenites Evae Mojs.
" *cf. Argonautæ* Mojs.
" *cf. Dianæ* Mojs.
Didymites tactus Mojs.
Pinacoceras parma Mojs.
" *Metternichii* Hauer, *var.*
Arcestes dicerus Mojs.
Cladiscites cf. neortus Mojs.

To this list of noric types must be added 6 species of *Distichites* (*megacanthi*), 3 species of *Drepanites* and of *Didymites*, 4 species of *Ectolcites*, 2 species of *Stenarcestes*, 1 species each of *Dionites*, *Acanthinites* and *Daphnites*—genera which up to now have only been found in the noric stage of the Hallstatt limestone. It is especially the genus *Didymites*, restricted to the alaunic (middle noric) sub-stage in Europe, which is very richly represented in the Tropites-limestone at all localities from which collections have been made by Smith and A. v. Krafft.

The fauna of the Tropites-limestone of Byans has also close affinities to that of the Halorites limestone of the Central Himálayas (Bambanag section) of lower noric age. The following species are common to both horizons:—

Steinmannites Lubbocki Mojs.
Tibetites Ryalli Mojs.
Anatibetites Kelvini Mojs.
Paratibetites Adolphi Mojs.
" *Bertrandi* Mojs.
" *Geikiei* Mojs.
Parajuvavites Jacquini Mojs.
Pinacoceras parma Mojs.

As elements pointing to a close relation with the fauna of the Halorites beds must be mentioned moreover—

Paratibetites sp. aff. Tornquisti Mojs.
Halorites sp. aff. procyon Mojs.
Clionites sp. aff. Hughesii Mojs.
" *sp. aff. aberrans* Mojs.
Sandlingites sp. aff. Archibaldi Mojs.
Bambanagites Kraffti nov. sp.

The representatives of *Tibetites* (including the two sub-genera *Anatibetites* and *Paratibetites*) are scarcely inferior to the genus *Tropites* in number of individuals.

The total number of species of ammonites with noric affinities in the Tropites-limestone of Byans is 49, or one-third of the entire number of species.

The above analysis shows that the cephalopod fauna of the Tropites-limestone of Byans has relations with *both the carnic and noric faunæ* of the Hallstatt limestone. Such an assemblage of forms has never been met with in any Triassic horizon of the Eastern Alps, where noric and carnic faunæ are invariably confined to entirely different horizons.

This strange association of faunistic elements in a single bed of three feet in thickness offers a problem, the explanation of which may be attempted from different points of view.

The easiest explanation would be to suggest that the two faunæ have been mixed together accidentally in the collections from different localities. Two deposits of equal lithological characters might easily be mistaken for a single horizon, although they contain two separate faunæ, if a careful examination of the fossils is not possible in the field. If each of the two faunæ of the Tropites-limestone were found concentrated in the collections of a single locality and not mixed there with the second fauna, we might take this explanation as the fittest.

A detailed examination of the lists of fossils from different localities has, however, convinced me that the noric and carnic faunæ do not occur at separate localities but are amalgamated in the Tropites-limestone at every locality from which collections have been made. Thus we are led to the conclusion that two faunæ, which in the Alpine Trias are known to characterise two horizons of different geological age, have in Byans been found mixed together in one single bed of three feet in thickness.

It must be especially remarked that A. v. Krafft, when surveying the Mesozoic territory of Byans, did not overlook the remarkable mixture of two different elements in the fauna of the Tropites-limestone. I quote the following passage from his diary:—

"Palæontologically the fauna of the Tropites-limestone is very remarkable. The genus *Tropites* being very common and *Tropites subbullatus* occurring among other species, the fauna must be nearly allied in age to that of the *subbullatus*-beds of the Salzkammergut. But with these upper carnic types forms occur which bear a strong resemblance to species from the limestone of the Sommeraukogel near Hallstatt, considered to be of noric age by E. v. Mojsisovics. No explanation of this fact can be attempted so far."

In the face of these facts it is impossible to maintain the suggestion that the noric and carnic faunæ contained in the Tropites-limestone of Byans have been mixed together accidentally in the collections from different localities.

It is a well-known fact that in the entire Alpine Trias there is no greater gap in the development of faunæ than between the noric and carnic stages. The question arises, whether the strange association of carnic and noric elements in the Tropites-limestone of Byans might not constitute a transitional fauna, bridging over the hiatus which exists between the carnic and noric stages of the eastern Alps. If this suggestion could be proved to be correct, the Tropites beds of Byans might be considered as passage beds from the tuvalic (upper carnic) into the lacic (lower noric) sub-stage.

This suggestion is, however, not confirmed by any facts. There is only an extremely small number of transitional forms connecting the two faunæ. As such connecting links might be considered *Placites polydactylus var. Oldhami* Mojs., a group of *Dittmarites* uniting characters of *D. Dorceus* Mojs. of carnic and of *D. Lilli* Guembel of noric age, *Buchites Emersoni* nov. sp., a representative of the carnic sub-genus *Buchites* but very nearly allied to the noric sub-genus *Phormedites*. But this is a very small number, whereas the overwhelming majority of ammonites in the Tropites-limestone are allied to either carnic or noric types, but do not constitute transitional forms between the two faunæ.

It has been stated that among the carnic elements of the fauna of the Tropites-limestone two groups can be distinguished, one with tuvalic, the other with julic affinities. In the noric elements of the fauna similar relations with the faunæ of the lacic and alaunic sub-stages are obvious. There is undoubtedly a preponderance of lacic affinities in them, but the affinity to the alaunic sub-stage is nevertheless sufficiently remarkable. This affinity is most clearly marked in the presence of *Didymites* and *Ectolcites,* two genera, which in the Alpine Trias are restricted exclusively to beds of alaunic age.

A fauna with so strange a mixture of julic, tuvalic, lacic and alaunic types, does certainly not exhibit a transitional character. It is widely different from the fauna of a passage-bed between the tuvalic and lacic sub-stages, in which we should expect an overwhelming preponderance of exclusively tuvalic and lacic species and of transitional links connecting them. The Tropites-limestone can consequently not be considered as a passage bed, but is a horizon distinguished by the mixture of two different faunæ.

This mixture of faunæ agrees in a remarkable manner with the association of Kelloway and Oxford ammonites in the Jurassic oolite of Balin (Galicia). As has been proved by Neumayr (*Abhandl., k. k. Geol. Reichsanst.,* Bd. V, 1871) the oolite of Balin contains in a very thin bed 66 species of ammonites of Kelloway and Oxford age, ranging from the zone of *Oppelia aspidoides* to the zone of *Quenstedtoceras Lamberti.* It would be in contradiction with our knowledge of the distribution of Jurassic ammonites to suppose, that two faunæ, which in all other parts of the world have been found confined to geologically different horizons, had lived together at the same period in the sea, in which the oolite of Balin was deposited. As in analogous cases the want of sediment seems to be the chief cause of the mixture of Kelloway and Oxford types at Balin.

Taking all this into consideration we are led to the conclusion that the Tropites-limestone is not only a homotaxial equivalent of the *Subbullatus*-zone of Europe, but also an equivalent of the lacic Halorites beds of Johár and Painkhánda, with which it has a considerable number of species in common. The intimate connection of carnic and noric faunæ in this thin bed of limestone might be explained by the small amount of sediment deposited during the tuvalic and lacic periods. With this suggestion the remarkable reduction in the thickness of all Triassic sediments in the Himálayas from Spiti to Byans would be well in accordance.

In Spiti the ladinic stage amounts to approximately 300 feet and is overlaid by strata of carnic age, 1,300 feet in thickness. In the Bambanag and Shalshal sections the ladinic stage dwindles down to such an insignificant extent, that Griesbach and myself failed to discover it in 1892, but the carnic stage is still represented by shales and limestones 800 feet in thickness. In Byans muschelkalk, ladinic and carnic stages are represented by a lithologically uniform mass of grey limestone of 200-250 feet in thickness. Counting 70 feet for the muschelkalk, the maximum thickness of the carnic stage cannot be more than 180 feet (800 in Johár, 1,300 in Spiti).

If we suppose that the sedimentation was nearly exhausted in the seas of the upper carnic and lacic periods, the entire result of sedimentation during those periods might have been a lithologically uniform bed of limestone, three feet in thickness. Then it would be impossible to separate carnic and noric fossils within this limestone. This is exactly the case we find in the Tropites-limestone of Byans, which contains in a single bed the faunæ of two different Triassic horizons.

ON THE OCCURRENCE OF AMBLYGONITE IN KASHMIR. BY F. R. MALLET, *late Superintendent, Geological Survey of India.*

IN 1881, or early in the following year, an important discovery of sapphires was accidentally made in the Zánskár Range of the Himálayas, and considerable quantities of the mineral, including many valuable gems, were subsequently obtained.[1] The yield, however, some years later, was steadily diminishing, in consequence of which the Kashmír Darbár, in 1887, applied to the Government of India for a Geologist to examine the mines, and Mr. T. D. LaTouche was detailed for the duty in question. It appears from the results of his investigations, which are given in *Records*, Vol. XXIII, p. 59, that the mines, or more correctly diggings, are situated at an elevation of over 13,000 feet, about two miles west-north-west from Sumjám, a village in the district of Pádar, in N. latitude 33° 25′ 30″, E. longitude 76° 28′ 10″.[2] Although most of the sapphires were obtained from loose débris fallen from the cliffs above, the original matrix of the gems, in which they were actually found *in situ*, was a (generally pegmatitic) granite that traverses the gneiss of the surrounding hills in numerous dykes, though the sapphires were only observed in some particular ones. Other accessory minerals observed were black tourmaline, euclase, kyanite, and garnet.

"Besides the corundum,"[3] LaTouche continues, "several other minerals, interesting from a scientific point of view, though not commercially valuable, are found in the granite of this region. For a determination of the species of most of these I am indebted to Mr. F. R. Mallet, late of the Geological Survey, who kindly examined them for me. These are the following:—1, green tourmaline; 2, cookeite; 3, spodumene; 4, prehnite; 5, copper carbonate; 6, beryl; 7, lazulite; 8, rock-crystal; concerning the third of these the author writes, "a few lilac-coloured crystalline blocks of this mineral,

[1] *Records*, Vol. XV (1882), p. 138, and Manual of the Geology of India, Part IV, p. 40.

[2] The village (with the name spelled Sunjám) is marked on Lydekker's geological map of Kashmír, *Mem. G. S. I.*, Vol. XXII.

[3] Sapphire.

which also[1] contains lithia, were found in a valley to the north of the Sapphire mines, between them and the place where the green tourmalines were found: none of these were found *in situ.*" The green tourmaline was discovered about a mile from the ridge in which the sapphires occur.

As mentioned by LaTouche, I determined some of the above, but not the remainder, and amongst the latter was the mineral alluded to as spodumene. When retiring from the survey, however, I brought home a few Indian minerals, with the permission of Dr. King, the then Director, in the hope of being able to examine them at some future time, and amongst them was a piece of the mineral in question.

The physical and chemical characters of the specimen show that it is *amblygonite*, a mineral sometimes found in association with spodumene, and resembling it in containing alumina and lithia as the principal bases; but the acidic element is phosphoric instead of silicic.

The specimen is cleavable massive, with one fairly perfect cleavage, and another only faintly developed. Fragments suitable for goniometric measurement are obtainable with extreme difficulty. One excellent morsel, however, was found, with smooth planes yielding good reflections, and giving a measured cleavage angle of 104° 58′. The hardness is 6; the specific gravity 3·05; and the colour pale bluish gray to faint violet. The mineral is unusually transparent for amblygonite: thus the print of these *Records* could be easily read through a parallel-faced cleavage fragment nearly half a centimetre thick—the thickest obtainable without flaws. Solid inclusions are very rare or absent: some parts are free from inclusions of any kind, while in others there are numerous minute cavities, and some larger ones, which are partially filled with liquid. A few of the bubbles are moveable. Analysis showed that the principal constituents of the mineral are phosphorus pentoxide, alumina, and lithia, with minor proportions of soda, potash, fluorine, and water. It resembles the amblygonite of other localities by its occurrence in granite, and in its association with other lithia-minerals, represented in the present case by green lithia-tourmaline and cookeite.

The above is the only locality where amblygonite has been found within the limits of the Indian Empire, and I may add that none of the works on mineralogy I have consulted mention its occurrence in any part of Asia.

[1] *i.e.,* in common with the cookeite.

MISCELLANEOUS NOTES.

The Kangra Earthquake of 4th April, 1905.

AFTER a lapse of only eight years since the great earthquake of 1897, India has again been visited by another disaster of considerable magnitude, namely, the Kangra Earthquake of the 4th April, 1905, by which an unfortunate loss of human life occurred, estimated at 20,000. An investigation was immediately taken in hand by this Department among others, not only by sending officers personally to the affected parts, but by the issue of many thousand question-forms to local officials throughout the various Presidencies and Native States. The facts and information thus collected are now being arranged and sifted, and the first result will appear in the next issue of the "Records" as a preliminary account. Meanwhile, it may be summarily stated that the quake appears to have originated in a geotectonic movement taking place below an epifocal area some 160 miles long and extending in a north-west—south-east curve from the neighbourhood of Kangra to that of Mussoorie. It seems to have been connected with a reversed fault or series of related faults intimately bound up with the structural history of the Himalaya. This axial form of centrum must have had a distinct pitch to the south-east, whilst it emerged quite near the surface in the Kangra Valley and gave rise at that locality to a destructive intensity of 10 of the Rossi-Forel scale. On account of its increasing pitch towards the south-east, the intensity along the epifocal tract diminished to 9 in Kulu, and to about 8 near Mussoorie and Dehra Dun. In other words, the first few isoseismals close up round the north-west end of the centrum and widen out towards the south-east. The area of extensive damage to masonry buildings is only about 5,800 square miles as compared with 150,000 square miles in the Assam earthquake of 1897; whilst a further area of 27,000 square miles, surrounding the former, represents that of slight, but still frequently destructive damage to masonry buildings. On the other hand, the isoseismals of still more diminishing intensity expand out relatively, especially along the Indo-Gangetic alluvium; so that finally the total area over which the shock was sensibly felt works out not far below that of the 1897 quake, its western, southern and eastern limits being, respectively, Quetta, Surat, False Point, and Lakhimpur.

The unfelt earthquake, besides being recorded by the seismographs of Calcutta, Bombay, and Kodaikanal in India, was of world-wide effect, and has furnished long-distance traces to the instruments in Europe and Japan.

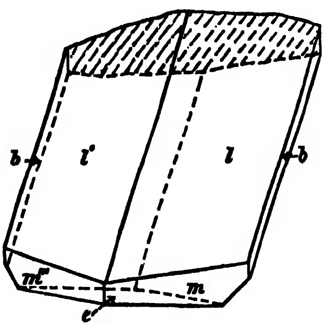
[C. S. MIDDLEMISS.]

An unusual form of Selenite from the Pachpadra Salt-Source, Jodhpur, Rajputana.

Selenite or Gypsum.

Some interesting samples of various substances obtained during the manufacture of salt from the brine obtained from brinewells at Pachpadra, and regarded as impurities, were forwarded by Mr. A. F. Ashton, Officiating Commissioner, Northern India Salt Revenue, Agra, to the Geological Survey Office for examination. One sample is impure Epsom salt and the remainder consist of selenite sometimes associated with common salt.

The most interesting of these specimens is locally called *anetha* and consists entirely of selenite crystals. These were sorted into three portions. The first (J. 843) consists of crystals of unusual habit. As will be seen from the accompanying figure, owing to the subordinate development of the faces *m* (110) and *b* (010), the pyramid faces *l* (111) become the most prominent and this, aided by the presence of the hemiorthodome *e* (103), causes the crystals to assume a flattened aspect roughly parallel to the negative hemi-pyramid (111).



The face (*e*) is exceedingly roughly developed and is not always present. In colour they are usually creamy, more or less opaque, and often show zoning on the faces *l*, *l'* parallel to the edges *lm* and *lb*. The largest crystals measure about $\frac{3}{4}$ inch along the edge *ll'* and are $\frac{3}{16}$ to $\frac{1}{4}$ inch thick.

The second portion of these crystals (J. 844) consists of many small swallow-tail twins ranging up to $\frac{1}{2}$ and $\frac{3}{4}$ inch across the "tails," and having *a* (100) for twinning plane. They usually have the normal development of selenite crystals, *i.e.*, tabular parallel to *b*, but are occasionally of the preceding type.

The third portion (J. 845) consists of many more or less radiate aggregates of small crystals averaging $\frac{1}{4}$ to $\frac{1}{2}$ inch in length, some of the crystals showing the abnormal habit of J. 843, while some are twinned.

[L. L. FERMOR.]

G. I. C. P. O.—No. 474 D. G. Survey—20-10-05.—660—H. R.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1905. [November.

MEDLICOTT AND BLANFORD.

THE joint-authorship of the first Manual of Indian Geology has served to link together the names of Medlicott and Blanford in the minds of many scientific men, who were not aware of the close partnership which existed between these two great men from the time they joined the Indian Service just fifty years ago. Now both have passed away in the same year and in the order of seniority observed throughout their official careers. When the news of Mr. Medlicott's death reached India in April last, Dr. Blanford, as the one conspicuously most suitable, was asked to review his friend's services to science; but before the note printed below could be set up in type, or its receipt even acknowledged, the sad news arrived that its author too had gone: the last effort of a literary activity, hardly surpassed in the history of science, was thus spent characteristically on an appreciative memorial to a fellow-worker.

[T. H. HOLLAND.]

H. B. MEDLICOTT, M.A., F.R.S.

HENRY BENEDICT MEDLICOTT was born at Loughrea, County Galway, Ireland, on August 3rd, 1829. He was the second of three sons of the Rev. Samuel Medlicott, Rector of Loughrea, and of Charlotte, daughter of Colonel H. B. Dolphin, C.B. His elder brother, Joseph G. Medlicott, was also for several years on the staff of the Geological Survey of India. Henry Medlicott was educated in France, Guernsey, and Dublin, where he graduated at Trinity College and took the degree of A.B. in 1850, with diploma and honours in the School of Civil Engineering. He took the M.A. degree in 1870.

He was thus, from his early education, an excellent French scholar, and his acquaintance with the classical works of the great French geologists may be often traced in his writings.

In 1851 he joined the Geological Survey in Ireland, and in 1853 he was transferred to the English Survey, where, for a time, he worked with Mr. Aveline in Wiltshire. He was then engaged by Dr. Oldham for India, and joined the Geological Survey, then occupied in the Rájmahál Hills, at or near Bhagalpur, on March 24th, 1854. His brother, J. G. Medlicott, had joined the Survey a year or two earlier. Before, however, Henry Medlicott had commenced field work, he was appointed, in August 1854, by the Court of Directors of the East India Company, Professor of Geology in Rurki College, and he remained in this post till October 1862, when on some additions being made to the staff of the Geological Survey, he rejoined it as Deputy Superintendent for Bengal.

During his tenure of the Rurki Professorship, however, he did most important work in field geology. By an arrangement with Dr. Oldham he was allowed to occupy the field season in surveying, and thus he was enabled to examine part of the Nerbudda Valley and Bundelkhand in 1854-55 and in 1856-57, whilst in the other years he was engaged in working out the geology of the Lower Himálayas between the Ganges and the Rávi (Hardwar to Dalhousie) and of the Siwálik beds and their associates at the base of the mountains. In 1857 he served as a volunteer, with the garrison of Rurki, against the mutineers of the Bengal army, and on the close of the campaign was awarded the Indian Mutiny Medal for Special Service. An instance of the service rendered may be added here.

Rurki, during the outburst of the sepoy mutiny, was isolated, like most of the small garrisons in the Upper Provinces, where the natives of the villages were associated with the rebels. No European could possibly traverse the country in safety. News was received at Rurki, one day, of a Christian family who were held by the villagers as prisoners at a few miles' distance, and who were in imminent danger of being killed. It was arranged that Henry Medlicott and one other European companion should go out with an escort of sowars to endeavour to rescue these unfortunate people; but on the day before the attempt, the sowars showed signs of mutiny and were disarmed. Medlicott and his companion, whose name appears now impossible to trace, left in the morning, and by sheer pluck, at the risk of their lives, succeeded in bringing back the imprisoned people in safety, the villagers apparently being so astonished at two Europeans coming among them that they surrendered their prisoners. Only the outline of the story can be recovered: it was told to the present writer in 1866 by Colonel Baird Smith, who commanded the Rurki garrison in 1857.

After rejoining the staff of the Geological Survey in 1862, Mr. Medlicott was engaged for many years, first in one part of the country, then in another, generally by himself, though occasionally in charge of a party, in enquiring into economical problems or in investigating geological questions, and not infrequently in clearing up difficulties that had proved too serious for his predecessors. In 1862-63 he was in South Rewah; in 1863-64 in Behar; in 1864-65 he traversed Assam from the farthest eastern extremity of the province to the Khasi Hills; in 1865-66 he was in Central India and Rajputana. In other years he examined various tracts from the Jammu hills of Kashmir, the Satpura ranges of the Central Provinces and Chhattisgarh to the Garo Hills in Assam. Twice he officiated as Superintendent of the Survey during Dr. Oldham's absence on leave, once in 1870 for a short period, and in 1873-74 for seventeen months.

On April 1st, 1876, Mr. Medlicott succeeded Dr. Oldham as head of the Survey, and from that time the duties of his office kept him mainly in Calcutta. The title of Superintendent was altered to that of Director in 1885, but the change was confined to the title.

Dr. Oldham had been in weak health for some time before he retired, and he naturally left many arrears for his successor to carry out. Foremost among these was the preparation of a general account of Indian Geology. This had long been required: a mass of scattered papers and reports, not a few of which were in manuscript, represented about a quarter of a century's progress in the systematic examination of Indian Geology, and before those who had helped from the beginning had left India for good, it was essential that they should prepare a record of the work in which they had taken part, for the information of their successors. Moreover, until a general description of the country as a whole was compiled, it was impossible for any one, either in India or in Europe, without an enormous amount of labour, to gain a correct idea of its geological features. Henry Medlicott at once set to work at this general account, and dividing the chapters between Mr. Blanford and himself, brought it to a conclusion in 1879, and published the "Manual of the Geology of India." It is unnecessary to point out the great importance of this book, or the assistance it has afforded not merely to Indian geologists, but to those throughout the world.

This, however, is only one of the subjects to which the new Superintendent of the Survey devoted his attention. Of the effect of his superintendence on the work of the staff, a fair example may be furnished by the Survey publications. From 1877 the *Records* which, as describing recent work, are the best illustrations of Survey progress, doubled in size, and they certainly did not fall off in the importance of the contributions printed, either economic or scientific. Besides these, Mr. Medlicott edited, during his tenure of office, about ten volumes of the *Memoirs*, and numerous parts of the *Palæontologia Indica*, comprising Dr. Feistmantel's descriptions of Gondwána plant fossils, most of Mr. Lydekker's accounts of the Siwálik and other vertebrata, and the largest portion of Dr. Waagen's great work on the Salt Range fossils, and of the descriptions of Tertiary corals and echinoderms from Western India by Dr. Duncan and Mr. Percy Sladen. There was the same thorough progress in other directions, for instance, in the arrangement of the Museum and Survey offices. His work absorbed him entirely. Living almost the life of a hermit, and confining himself to his office, he devoted all his time to the Survey. He was a man of retiring disposition originally, not in the least from want of energy or courage, but because the social pursuits of men in general did not attract him; he had, in fact, something of the ascetic temperament.

After the completion of his 55th year in 1884, Mr. Medlicott was retained by the Government in his office until 1887. He retired on April 27th in that year, having served almost continuously for rather more than 33 years. He was only on leave for 6 months in 1865, less than 6 months in 1871, and again 6 months in 1884, or 18 months during the whole period of service.

After his retirement he lived very quietly at Clifton near Bristol and took but little part in scientific discussion, though always keenly interested in the progress of the Indian Survey. His time, as long as he remained in good health, was mainly devoted to philosophical problems, to which he had always been devotedly attached. He published two short pamphlets on "Agnosticism and Faith" in 1888, and on "The Evolution of Mind in Man" in 1892, and was engaged on a large work which has not been finished. A few years since a strain caused by bicycling led to serious symptoms, and although for a time a partial recovery was made, a relapse early in 1904 reduced him greatly. The end came quietly on April 6th, 1905, when he was seated in his study.

Medlicott joined the Geological Society of London in 1856 and received the Wollaston Medal in 1888, on his retirement from the Indian Service. He was elected a Fellow of the Royal Society in 1877. He was a Fellow of the Calcutta University, and from 1879 to 1881 he was President of the Asiatic Society of Bengal. He was also Honorary Fellow of several Foreign scientific societies, but he never made use of his titles, which he regarded as simply "official." It may be remarked that he carefully omitted the letters F.R.S. after his name in all his Survey publications, and even in the "Manual" he struck out the initials after his own name, whilst leaving them after his colleague's. Throughout his career, in fact, he appears almost unnecessarily to have disregarded the honours to which he was entitled for brilliant original work as well as good official service.

His policy as head of the Survey was to assist his colleagues, in every way, to publish the account of their observations in their own words. Occasionally the result was that their views drew upon the authors replies from other officers, who took different views, or from geologists who had another opinion on the subject. This was especially the case in palæontological questions, on which he never pretended to decide difficult points. He published both views. The policy adopted is perhaps not quite in accordance with official usage, but there can be no doubt that the result of Medlicott's principle was to bring out the facts in a discussion, and not unfrequently in a difficulty of high scientific and economic importance, as in the various disputes over the Gondwána flora. And not only did he obtain the help of the staff of the Survey in forwarding the progress of Indian Geology, but he succeeded in securing the valuable assistance of the late General McMahon and others, who contributed observations on subjects of high interest in the geological history of the Indian Empire. That he contributed no lengthy memoirs of his own was simply due to the fact that he regarded with horror any attempt to gain credit by others' work. Short notes and an annual report were for many years his sole contributions to the Survey publications. He was not a fluent writer, though he could write strongly and earnestly, never so strong as when he was dealing with attempts at injustice or plausible but misleading statements. He was absolutely fearless, and cared but little whose pet theory he was disputing, if the theory was in his opinion worthless.

It is difficult to appreciate Henry Medlicott's work in India without some acquaintance with the knowledge of the geology available when he entered the Service. So great a change has taken place in the half century that has elapsed since 1854, that it is scarcely possible to reconstruct the conditions under which geological surveying was carried out fifty years ago. There were no railroads and very few roads. Travelling was difficult and very slow. The early surveyors had often to make their own maps in the wilder parts of the country. Some idea of the geology known in the days before the Survey may be gained from Dr. H. J. Carter's Summary of the Geology of India between the Ganges, the Indus, and Cape Comorin, published in 1854, the year that Mr. Medlicott landed in India. In this remarkable work, to take only one instance out of many, Vindhyans and Gondwánas, both upper and lower, with limestones from every formation in India, from metamorphics to the Bágh beds and intertrappeans, are included in the "Oolitic Series." An equally remarkable confusion is shown by Greenough's Geological Map of India published about the same time.

Nothing had been done to clear up the nebulous condition of Indian Geology before 1854. Henry Medlicott's first season in India was signalised by the earliest and most important step in the classification of the Peninsular rocks. He and his brother, J. G. Medlicott, separated the Vindhyans north of the Nerbudda valley from the Gondwánas to the south. The name Vindhyan was given by Dr. Oldham, who, however, when announcing the discovery (*Journal, Asiatic Society, Bengal*, 1856, vol. XXV, p. 250, and more clearly *Memoirs, Geological Survey, India*, vol. II, p. 304), stated that the separation had been made by the Medlicotts before he visited the country. In the first memoir he wrote (vol. II of the *Memoirs*) Henry Medlicott reduced the whole mass of Vindhyans, infra-Vindhyans and Bijáwar rocks, that extend throughout Bundelkhand, to a sequence which has received no great subsequent alteration, the principal change, perhaps, being in the substitution of the term Lower Vindhyans for Sub-Kymores. This masterly paper, though published in a most imperfect condition, ill-arranged and not very clearly written, was not only the beginning of our accurate knowledge of the Vindhyan and infra-Vindhyan rocks, but a firm foundation on which much since has been built. From his earliest work to his latest, these wonderful azoic rocks of India were Mr. Medlicott's especial favourites, perhaps because all the knowledge of them was derived from purely physical observations, and not interfered with by organic remains, which in the younger Gondwánas have not always proved an accurate indication of the age of the beds or their relations to each other. Throughout the annual reports issued during his Directorship, point after point is brought forward tending to the correlation of these formations in various parts of India, and showing the relations between Kurnool and Cuddapah, Kaládgi, Gwalior, and many other similar rocks on the one hand, and the Vindhyan and Bijáwars on the other.

The next great work of his was the arranging of the rocks of the Lower Himálayas in the Simla and neighbouring areas, and of the Siwálik rocks and their associates at the base of the mountains, and of first sketching the history of the Himálayan range on a definite geological basis. The first named has been one of the most difficult questions in Indian Geology, and although the work was commenced in 1855, it cannot be regarded even now as nearly solved. The Tertiary Himálayan beds have, however, been fairly classified since Mr. Medlicott's memoir was published in 1864. The important observations made in this memoir are essentially physical. The demonstration that Himálayan elevation is shown, by the relations of the lower nummulitics to the older hill rocks, not to have begun before Tertiary times, and the beautiful illustration proving the permanence of the great river valleys by their coincidence with the maximum of conglomerates in the Siwáliks are amongst the observations that connect our first clear ideas of Himálayan elevation with Henry Medlicott's work.

It has been already noticed that not unfrequently Medlicott was occupied in clearing up difficulties that had been too great for his predecessors in the Survey. An illustration may be taken from the geology of the Khási Hills. A comparison of his observations as recorded in the VIIth volume of the *Memoirs*, should be made with the earlier account of the same area in the 1st volume. In the first account, amongst other differences, the bedded Sylhet traps (Mesozoic) are not distinguished from the ancient greenstone rocks of the inner hills, and the occurrence of fossiliferous Cretaceous rocks was not recognized; their fossils, then supposed to have been nummulitic, having been lost. The alterations that were made in the geology by Medlicott may be seen by comparing the map and section on Pl. VIII in vol. I, with the map and section at p. 154 in vol. VII. The earlier observations, it is true, were made in the monsoon, when, of course, the ground was not so well exposed. Again, the sketch map of the Satpura or Nerbudda coal area as corrected by Henry Medlicott in vol. X of the *Memoirs* may be compared with the earlier map published in vol. II. It was quite true that the principal discrepancy in this case is easily explained. J. G. Medlicott, who not merely geologically examined the country, but who also to a considerable extent surveyed the map, had practically completed the western portion containing the typical Mahadevas, without separating them from the underlying Damudas, when, in the early part of 1856, Dr. Oldham, the head of the Survey, went over the field, and almost at the end of the season, discovered that the Mahadeva was a separate series. The attempt to record this distinction on the map led to some confusion which was subsequently straightened by Medlicott.

Almost his only important geological paper published outside the Survey publications was that on "The Alps and the Himalayas, a Geological Comparison," issued in the *Quarterly Journal of the Geological Society* for 1868, vol. XXIV. This paper narrowly escaped rejection; it was postponed for a time, but finally published. Nor was this wonderful, for it attacks, and in no doubtful way, the conclusions of all the great Alpine geologists, von Hauer, Gümbel, Studer, Desor, and others, and there is no question that in the main Medlicott was right. Some of the views expressed by him required, and have since received, revision; but as an original description of mountain-building from uniformitarian views as opposed to catastrophic it is worth far more attention than it has received.

There can be no question of his uniformitarianism. One of his objections to some of his colleagues' work was to their use of faults to explain abrupt boundaries. It is, however, characteristic of his love of truth that when Mr. R. D. Oldham found that the typical Náhan-Siwálik section, to which Henry Medlicott had so long referred as an example of deposition against a pre-existing cliff, might be a fault after all, he revisited the section and in the simplest manner admitted that he had misunderstood it (*Records, Geological Survey, India,* XIV, 1881, p. 169). Only those who remembered the whole controversy about faults can have any idea of how great a blow to his theories this must have been, and there are few Directors of Surveys of whom it could be said that an error of so much importance was so frankly acknowledged.

On the large question, whether, for instance, the great lines terminating the Gondwána basins of Bengal, Orissa, and the Central Provinces are simple faults, or whether they represent the boundaries of the old river valleys to which the beds were limited, these boundaries having been subsequently slightly crushed and distorted, but not greatly faulted, is a question to which a complete answer has not yet been given. In some cases at least, for instance in the Mohpáni field of the Sátpuras, strong evidence was brought forward by Medlicott in favour of his views of his original limit, and even in the case of Rániganj, where unquestionably considerable faulting exists, the absence of outliers of the coal-bearing rocks south of the field is a difficulty in supposing that a simple great upthrow alone terminates the Gondwána area. Between the two authors of the Manual of Indian Geology there was a difference of opinion on this point, and it cannot be said that the question is finally decided.

The above may serve to recall a few of the services of Henry Medlicott to the Geological Survey and to India, and some of the discoveries which he made in science. It cannot do more than suggest the amount of labour that he devoted to his work. His memory should remain as a striking example of a thoroughly honest and capable geologist and as a worthy head of a scientific branch of the Indian Government Service.

[W. T. BLANFORD.]

W. T. BLANFORD, A.R.S.M., LL.D., C.I.E., F.R.S.

WILLIAM THOMAS BLANFORD was born in London on the 7th October 1832, and was educated at Brighton and in Paris. After a short interval of business life in Italy and London he matriculated in 1852 at the Royal School of Mines, London, where, with his younger brother, the late Henry F. Blanford, F.R.S., he had the privilege of training under a group of famous teachers in science—Lord Playfair, Sir Andrew Ramsay, Sir Warington Smyth, Edward Forbes, and T. H. Huxley under the directorship of Sir Henry De la Beche. The Blanford brothers successively headed the list of candidates at the final examinations, each in his year receiving the Duke of Cornwall and the Council scholarships. After further training at the Freiberg School of Mines, both brothers were appointed to the Geological Survey of India and joined at Calcutta in September 1855.

Henry Blanford some years later was transferred to organize the Meteorological Department, whilst his brother remained in the Geological Survey until his retirement from the service in 1882.

A simple extract from the annual distribution lists will show the wide experience obtained, and, to those who knew him, the great influence exercised by W. T. Blanford on Indian Geology:—1855-56, Orissa coalfields; 1856-57, Rájmahál hills; 1857-58, the Orissa coastal tracts; 1858-59, Ránigan coalfield, Trichinopoly, Nilgiris, Birbhum; 1860, Pegu; 1861, Upper Burma; 1862—65, various parts of the Bombay Presidency, Sind, and Central Provinces; 1866, Godávari area, Central Provinces; 1867-68, Abyssinia; 1869-70, Wardha valley, Central Provinces, Sikkim; 1870-71, Lower Godávari, Madras Presidency; 1871-72, Sind and Persia; 1874-75, Surát and Sind; 1876, Rájputána; 1877—1879, Calcutta; 1881-82, Baluchistán and Punjab.

During this period, when much of his time was occupied by purely official routine work and in travelling, at a time when neither railways nor roads were developed in India as they are now, Mr. Blanford published just 150 scientific papers, many of which were large memoirs, all descriptive of original work, not merely details of observation, but contributions to the philosophical aspects of geology and zoology which have made some of these papers classical works. His services to science were naturally recognised in Europe: in 1874 he was elected a Fellow of the Royal Society; in 1881, whilst representing India at the International Geological Congress at Bologna, he was elected a Vice-President of the Congress, and was decorated by the King of Italy with the Order of St. Maurice and St. Lazarus. He was also Vice-President of the Congress on three subsequent occasions—Berlin 1885, London 1888, and Paris 1900. On his retirement from the Indian Service in 1882, the Geological Society of London conferred on him the highest distinction at their disposal, the Wollaston medal. In 1884, he was selected President of the Geological section of the British Association at Montreal, and at the same time the McGill University conferred on him the honorary degree of LL.D. He was elected President of the Geological Society of London in 1888, served three times as Vice-President of the Royal Society, and on other occasions as Vice-President of the Zoological and the Royal Geographical Societies.

Although much of his time was taken up after his retirement with his duties as a member of Council or as an office-bearer in the various scientific societies of which he was such an active member, Dr. Blanford added another 24 papers to his enormous record of scientific work, these including three volumes of the Fauna of British India, and his well known memoir on the distribution of Indian vertebrates, for which he received the Royal medal of the Royal Society in 1901.

Those who enjoyed the inestimable privilege of his friendship will agree that Blanford's enormous record of published work was not greater than that which he freely contributed to friends in private correspondence. Amidst his duties at home he never failed to respond to a question or difficulty presented by the most junior member of his old Department: no section of Indian Geology appeared to be too small or local to be considered worthy of his earnest attention, and times without number, during the recollection of the writer, by private correspondence he has given his successors new lines for profitable research, pointed out, by his unique knowledge of literature and width of experience, the significance of new observations, and has frequently saved his less experienced juniors from the pitfalls of hasty deductions drawn from imperfect data in this country, where the paradoxical character of the Geology is as liable as its Sociology to exemplify in the new-comer the dangers of a little learning.

It would not be possible in a few pages to even enumerate the many ways in which Blanford influenced the lines of Indian Geology, as well as moulded the working principles of the science generally. But possibly the feature of his career of most interest to India was the way in which he brought his wonderfully wide range of information, and his well known ability to sift the value of apparently contradictory evidence, to bear on the tangled controversy with regard to the age of the Gondwána system. Dr. O. Feistmantel, the official Palæontologist of the Department, who was mainly a palæobotanist, following with conservative faithfulness the accepted principles of correlation with the European order of succession, enumerated the plant forms occurring in the different stages of the Gondwána beds, and by comparison of them with the types known in European systems, placed the lower (Talchir) limit of the Gondwánas on a level with the European Trias, whilst the uppermost beds in Cutch he correlated with the Lower Oolite [1]. Dr. Blanford, however, laid stress on the greater value of marine forms in the Cutch beds as indicating an age for the uppermost Gondwánas as young as the uppermost Jurassic of Europe, whilst as

[1] O. Feistmantel. *Rec. Geol. Surv. Ind.*, IX, 28 and 63, 1876.

regards the lowest stages he brought in indirect evidence obtained in Australia, where similar fossil plants having a Mesozoic facies were associated with, and even lying below, undoubtedly Palæozoic marine beds. He thus showed the accuracy of the opinions previously expressed by T. Oldham and H. F. Blanford with regard to the Palæozoic age of our productive coal measures.[1]

Following up this subject in his Presidential address to the Geological section of the British Association at Montreal in 1884, he summed up a mass of biological statistics to account for the apparent contradictions in the order of succession of plants and animals in the beds of intermediate position and age, demonstrating the truth of the prevision made fifteen years before by Huxley, that on isolated land-areas animals and plants have their own special rates of evolutionary development, and that it is only by the forms living in the ocean, under more uniformly distributed physical conditions and with greater freedom for migration, that approximate contemporaneity can be obtained in stratigraphical correlation.

Five years later, as President of the Geological Society of London, Dr. Blanford was able to assume without question the truth of the Gondwána proposition, and from it to draw conclusions affecting the much debated question of the permanence of oceanic depressions and continental plateaux. He then brought together in his inimitable way a mass of apparently isolated and unrelated data to show that, "not only is there clear proof that some land-areas lying within continental limits have at a comparatively recent date been submerged over 1,000 fathoms, whilst sea-bottoms now over 1,000 fathoms deep must have been land in part of the Tertiary era, but there are a mass of facts both geological and biological in favour of land-connection having formerly existed in certain cases across what are now broad and deep oceans."

Whether considered from the standpoint of a philosopher in his recognition of identity amidst apparent diversity in phenomena of independent branches of science, or regarded merely as a patient worker in the accumulation of descriptive detail, Dr. Blanford's record would place his name in the front rank of scientific workers. And to those who knew him the great range of his knowledge was no more remarkable than his unfailing generosity of disposition and courtesy of manner either to friend or opponent.

[T. H. HOLLAND.]

[1] W. T. Blanford. *Rec. Geol. Surv. Ind.* IX, 79, 1876.

As a Naturalist William Thomas Blanford has raised for himself a monument that will withstand the assaults of time, for it was patiently built of attested material upon a foundation of unique width. Whether as observer or writer, he will always be remembered as one of the foremost of those who brought Indian Zoology out of the region of chaos.

No one can be more wise than destiny; and by the nature of things the greater part of Blanford's zoological work was of a descriptive kind; but the imagination of an interpreter was constantly behind it.

Of this descriptive work, a very great part of which refers to collections made by himself, the earliest to appear in print (1860) was that on the Land and Fresh-water Mollusca of India and Eastern Asia. This was a subject in which, as a Geologist, he naturally had a particular and perennial interest, and the very last zoological paper that he wrote was one, describing some new Indian and Burmese species, published, just before his death, in the Proceedings of the Zoological Society.

Of his work in this field one of the most important results was a series entitled "Contributions to Indian Malacology," which appeared at intervals in the Journal of the Asiatic Society of Bengal between 1860 and 1880. Though chiefly of taxonomic value, these papers record numerous facts of anatomy, and are often animated by judicious observations upon such matters as geographical distribution, the interpretation of specific and varietal characters, the influence of environment, etc., all revealing the author's philosophic breadth of touch. That the final product of these critical investigations would form one of the volumes of his own "Fauna of British India" was an expectation that is, unhappily, unfulfilled.

While still busy in many other directions, Blanford, in 1867, made his first contribution to Indian Ornithology, the starting-point of a comprehensive series of papers, which, published from time to time during the following 27 years in various scientific journals, took finished shape in two of the four well-known volumes on Birds in the "Fauna of British India." In these two volumes all the birds except the Order of Passerines are included; and their treatment at the hands of an author who combined the qualifications of the expert, of the field-naturalist, and of the sportsman, appeals with equal appreciation to the trained Ornithologist and to that large company of educated people who take a general interest in living nature.

His connection, as Naturalist, with the Abyssinian Expedition of 1868, seems to have led Blanford to pay attention, among other things, to recent Reptiles and Amphibia; for between that year and 1881 he contributed to various scientific serials a number of papers in which many new species in these groups are described, chiefly from collections made during his own travels in north-western India, Baluchistan, and Persia, as well as in certain parts of the Peninsula. In respect of the reptilian fauna of the Indo-Persian desert region, Blanford came to be regarded as one of the leading authorities: here, as was generally the case, his knowledge of the fauna was part of a large organised knowledge of the country in its physical aspects and its geological history, acquired at first hand.

From 1868, too, dates Blanford's first published work on recent Mammals, another group of animals which he approached from many points of view. He was in working touch with Mammals for 35 years, and, as in the case of the Birds, his old experience was condensed into a volume in the "Fauna of British India"—another volume which is of the greatest use to the field-naturalist and amateur, without any detraction from its value as a standard scientific work.

In 1870 Blanford published his "Observations on the Geology and Zoology of Abyssinia," and in 1876 his "Zoology and Geology of Eastern Persia," the former dealing with land-vertebrates and mollusca, the latter with land-vertebrates alone. Both books are distinguished by that comprehensiveness, discernment, and balance, which characterize all their author's zoological work. His varied observations are digested: his materials are proportioned and attuned: and we get not merely a good description of a fauna, but also some notion of the manner in which the several differences of environment have affected its component parts.

Blanford's experience, grown ripe in bringing into order the results of 27 years of scientific survey of this and neighbouring countries, gave him such a unique position, that when, in 1883, he was chosen to organize an official work on the "Fauna of British India," it was felt that official and professional judgment were in complete accord.

Under his able editorship 18 volumes of this official serial have been published, and they include the whole of the Vertebrates and portions of 10 groups of Arthropods—chiefly Insects. Reference has already been made to Blanford's own contribution to the series—

the volume on Mammals, the first instalment of which appeared in 1888, and the two volumes on Birds, published in 1895 and 1898: these volumes, in their clearness and directness of style, in their moderation in matters of nomenclature and species-splitting, and in their freedom from all the delusions of faddism, are models of what a work of general reference should be.

The series is still far from complete; but to find a successor to carry it to a worthy conclusion—a successor possessing the ripe and varied knowledge, the fairness of mind, the tact, and the general wisdom of the first editor—will in truth be no easy task.

To those interested in the finer problems of zoology the most taking parts of Blanford's work are his essays on the geographical distribution of Indian animals. This subject, indeed, was at the back of all his systematic papers, and was separately treated by him, in a tentative way, as early as 1870. But in 1876 he published, in the "Annals and Magazine of Natural History," a critical and constructive paper, in which the elements of the Indian vertebrate fauna are segregated from a physiographical standpoint, their relations to the Ethiopian fauna are emphasized, and the argument that certain common elements suggest a vanished land-connection between South Africa and the Indian Peninsula is clearly stated.

Twenty-five years later the material accumulated in the compilation of the "Fauna of British India" was used by him for an exhaustive examination of this subject, and in 1901 he crowned his zoological work with an elaborate essay entitled "The Distribution of Vertebrate Animals in India, Ceylon, and Burma," which was published in the "Philosophical Transactions of the Royal Society."

In this fine monograph the entire land and fresh-water vertebrate fauna of the region is critically analysed by genera, and is split, by considerations of habitat, into definite geographical units: these, again, are recombined into subregions, the relations of which to each other, to neighbouring zoological regions, and to past geological land-connections and former geological climates being minutely and most effectively discussed.

It was characteristic of Blanford, in connection with this subject, upon which his profound knowledge of cognate branches of natural science entitled him to speak with authority, that his views were expressed with singular moderation. Though he was among the first to realize that modern zcological regions which ignore past geological changes *on the large scale* must be artificial, and, conversely, that instances of what are commonly regarded as anomalies of distribution may possibly afford corroborative evidence of those very changes, he allowed his opinions to mature before giving utterance to them.

No notice of Blanford as a Zoologist would be complete that failed to emphasize his telling personal influence, and his abundant sympathy with all who were in any way interested in the natural history of this country. It seemed to be natural to apply to Blanford, and natural to Blanford to sacrifice his time in order to help others. No man ever showed a warmer side to the amateur, or was so entirely free from the narrow prejudice of the professional. Of liberal intellect, of just and charitable temper, he was imbued with the true scientific spirit. In the annals of Indian Science—

> "*Notus in fratres animi paterni,*
> *Illum aget pennâ metuente solvi*
> *Fama superstes.*"

[A. W. ALCOCK.]

LIST OF SCIENTIFIC PAPERS BY W. T. BLANFORD.

1854. "On a section lately exposed in some Excavations at the West India Docks": Journ. Geol. Soc., x, pp. 433-435.

1856. (With Messrs. H. F. Blanford and Wm. Theobald,) "On the Geological Structure and Relations of the Talcheer Coalfield in the District of Cuttack": Mem. Geol. Surv. India, i, pp. 33-88.

1859. "Note on the Laterite of Orissa": Mem. Geol. Surv. India, i, pp. 280-294.

1860. "On the Rocks of the Damúda Group, and their Associates in Eastern and Central India, as illustrated by the Re-examination of the Rániganj Field": Journ. As. Soc. Bengal, xxix, pp. 352-358.

1860-1. (With Mr. H. F. Blanford) "Contributions to Indian Malacology": Journ. As. Soc. Bengal, xxix, pp. 117-127, and xxx, pp. 347-367.

1861. "Note on the Geological Structure and Relations of the Ránigunj Coalfield, Bengal": Mem. Geol. Surv. India, iii, pp. 1-195.

1861. "Note on a species of *Plectopylis*, Benson, occurring in Southern India": Ann. Nat. Hist., vii, pp. 244-246.

1862. "Contributions to Indian Malacology, No. 3: Descriptions of new Operculated Land-Shells from Pegu, Arakan, and the Khasi Hills": Journ. As. Soc. Bengal, xxxi, pp. 135-144.

1862. "Account of a Visit to Puppádoung, an Extinct Volcano in Upper Burma": Journ. As. Soc. Bengal, xxxi, pp. 215-226; Rep. Brit. Assoc., pt. ii, pp. 69-70.

1863. "On Indian Species of Land-Shells belonging to the genera *Helix*, Linn., and *Nanina*, Gray": Ann. Nat. Hist., xi, pp. 81–86.

1863. "On the Animals of *Raphaulus*, *Spiraculum*, and other Tube-bearing Cyclostomacea": Ann. Nat. Hist., xii, pp. 55-58.

1863. "Descriptions of *Cremnobates Syhadrensis* and *Lithotis rupicola*, two new Generic Forms of Mollusca inhabiting Cliffs in the Western Ghats of India": Ann. Nat. Hist., xii, pp. 184–187.

1863. "Contributions to Indian Malacology, No. 4: Descriptions of New Land-Shells from Ava and other parts of Burmah": Journ. As. Soc. Bengal, xxxii, pp. 320–327.

1864. "On the Classification of the Cyclostomacea of Eastern Asia" Ann. Mag. Nat. Hist., xiii, pp. 441–465.

1865. "Contributions to Indian Malacology, No. 5: Descriptions of New Land-Shells from Arakan, Pegu, and Ava, with Notes on the Distribution of Described Species": Journ. As. Soc. Bengal, xxxiv, pt. 2, pp. 66–105.

1865. "On the Manner of Occurrence of the Reptilian Remains found in the Panchet Beds of the Rániganj Coalfield, and on the probable conditions existing at the time when these rocks were deposited" [1865]: Pal. Ind. (Pret. Vert.), i, 1865–85 (pt. 1), pp. i-iii.

1865. "On the Stratigraphy and Homotaxis of the Kota-Maledi (Maleri) Deposits" [1873]: Pal. Ind. (Pret. Vert.), i. 1865-85 (pt. 2), pp. 17 (*bis*)-23.

1866. "Contributions to Indian Malacology, No. 6: Descriptions of New Land-Shells from the Nilgiri and Anamullay Hills and other places in the Peninsula of India: Journ. As. Soc. Bengal, xxxv, pt. 2, pp. 31–42.

1866. "Contributions to Indian Malacology, No, 7: List of Species of *Unio* and *Anodonta* described as occurring in India, Ceylon, and Burma": Journ. As. Soc. Bengal, xxxv, pt. 2, pp. 134–155.

1866. "On *Opisthostoma*, H. Blanford, with the Description of a New Species from the Neighbourhood of Bombay, and of the Animal and Operculum (*O. Fairbanki*)": Proc. Zool. Soc., pp. 447–451.

1867. "Descriptions of some Indian and Burmese Species of *Assiminea* (*A. cornea*, *A. subconica*, *A. marginata*, *A. rotunda*, *A. rubella*)": Ann. Mag. Nat. Hist., xix, pp. 381–386.

1867. "Stone Implements found in Central India": Proc. As. Soc. Bengal, pp. 136–138, 144-145.

1867. "Rediscovery of Franklin's *Certhia spilonota* (*Salpornis silonota*, Gray)" Ibis, iii, pp. 461–464.

1867. "On a New Species of *Callene* from the Pulney Hills in Southern India (*C. albiventris*. Fairbank)": Proc. Zool. Soc., pp. 832–834.

1867. "Note on the Geology of the Neighbourhood of Lynyan and Runneekote, north-west of Kotree, in Sind": Mem. Geol. Surv. India, vi, pp. 1–15.

1867. "On the Geology of a portion of Cutch": Mem. Geol. Surv. India, vi, pp. 17–38."

1868. "Description of *Fairbankia bombayana*, a new genus and species of

Rissoidæ from Western India": Ann. Mag. Nat. Hist., ii, pp. 399–401.

1868. "Contributions to Indian Malacology, No. 8; List of Estuary Shells collected in the Delta of the Irawady in Pegu, with Descriptions of New Species": Journ. As. Soc. Bengal, xxxvi, pt. 2, pp. 51–72.

1868. "Zoological Notes": Journ. As. Soc. Bengal, xxxvi, pt. 2, pp. 189–200.

1868. "Contributions to Indian Malacology, No. 9: Descriptions of New *Diplommatinæ* from Darjiling and the Khasi Hills": Journ. As. Soc. Bengal, xxxvii, pt. 2, pp. 77–83.

1868. "Natural History Notes made on a Voyage to Abyssinia": Proc. As. Soc. Bengal, pp. 65–66.

1868. "On the Zoology, etc., of Abyssinia": Proc. As. Soc. Bengal, pp. 83–86.

1868. "Notes on Abyssinia": Proc. As. Soc. Bengal, pp. 167–174.

1868. "Notes on a Journey in Northern Abyssinia": Proc. As. Soc. Bengal, pp. 276–287.

1868. "Monographie du genre *Cyathopoma*": Journ. de Conchyl., xvi, pp. 256–263.

1868. "Note sur les *Nicida*, section subgénérique des *Diplommatina* habitant la Péninsule de l'Inde": Journ. de Conchyl., xvi, pp. 330–336.

1869. "On the Animal and Operculum of *Georissa*, W. Blanf., and on its Relations to *Hydrocena*, Parreyss; with a note on *Hydrocena tersa*, Bens., and *H. milium*, Bens.,": Ann. Mag. Nat. Hist., iii, pp. 173–179.

1869. "Notes on some Indian and Mascarene Land-Shells": Ann. Mag. Nat. Hist., iii, pp. 340–344.

1869. "Descriptions of five Birds (*Hirundo æthiopica, Ruticilla* (?) *fuscicaudata, Phylloscopus habessinicus, Alauda prætermissa, Crithagra flavivertex*), and a Hare (*Lepus tigrensis*), from Abyssinia": Ann. Mag. Nat. Hist, iv, pp. 329–330.

1869. "Contributions to Indian Malacology, No. 10: Descriptions of New Species of *Cyclophoridæ*, of *Ennea* and *Streptaxis*, from the Hills of Southern and South-Western India". Journ. As. Soc. Bengal, xxxviii, pt. 2, pp. 125–143; Proc. As. Soc, Bengal, pp. 65–67.

1869. "Ornithological Notes, chiefly on some Birds of Central, Western, and Southern India": Journ. As. Soc. Bengal, xxxviii, pt. 2, pp. 164–191; Proc. As. Soc. Bengal, pp. 104–105.

1869. "On the Fauna of British India, and its Relations to the Ethiopian and so-called Indian Fauna": Rep. Brit. Assoc., xxxix (sect.), pp. 107–108.

1869. "On the Traps and Inter-Trappean Beds of Western and Central India": Mem. Geol. Surv. India, vi, pp. 137–162.

1869. "On the Geology of the Taptee and Lower Nerbudda Valleys and some Adjoining Districts": Mem. Geol. Surv. India, vi, pp. 163–384.

1869. "Descriptions of New Land and Fresh-water Molluscan Species collected by Dr. John Anderson in Upper Burma and Yunan": Proc. Zool. Soc., pp. 444–450.

1869. "On the Species of *Hyrax* inhabiting Abyssinia and the Neighbouring Countries": Proc. Zool. Soc. pp. 638–642.

1869-70. "On the Geology of a portion of Abyssinia": Quart. Journ. Geol. Soc., xxv, pp. 401–406; Phil. Mag., xxxix, p. 389.

1870. "On *Georissa*, *Acmella* (*Cyclostoma tersum*, Bens.), *Tricula*, and *Cyathopoma millium* Bens.": Ann. Mag. Nat. Hist., vi, pp. 368–370.

1870. "Contributions to Indian Malacology, No. 11: Descriptions of New Species of *Paludomus*, *Cremnoconchus*, *Cyclostoma*, and of *Helicidæ* from various parts of India" [1869]: Journ. As. Soc. Bengal, xxxix, pt. 2, pp. 9–25.

1870. "Notes on some Reptilia and Amphibia from Central India": Journ. As. Soc. Bengal, xxxix, pt. 2, pp. 335–376; Proc. As. Soc. Bengal, pp. 254–257.

1870. "On Faults in Strata": Geol. Mag., vii, pp. 115–118.

1870. "List of Birds obtained in the Irawadi Valley around Ava, Thayet Myo, and Bassein": Ibis, vi, pp. 462–470.

1870. "On the Coal Seams of the Tawa Valley, Baitool District, Central Provinces" [1868]: Rec. Geol. Surv. India, i, pp 8–11.

1870. "On the Coal Seams of the Neighbourhood of Chanda" [1868]: Rec. Geol. Surv. India, i, pp. 23–26.

1870. "Notes on the Route from Poona to Nagpur *viá* Ahmednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Hingunghat" [1868]: Rec. Geol. Surv. India, i, pp. 60–65.

1870. "Note on the Lead Vein near Chicholi, Raipúr District": Rec. Geol. Surv. India, iii, pp. 44–45.

1870. "Report on the Coal at Korba in the Bilaspur District": Rec. Geol. Surv. India, iii, pp. 54–57.

1870. "Note on the occurrence of Coal east of Chatisgarh in the country between Bilaspúr and Ránchi": Rec. Geol. Surv. India, iii, pp. 71–72.

1870. "Observations on the Geology and Zoology of Abyssinia, made . . . in 1867-8": pp. xii, 487, 13 pls., 1 map, text-illustration; London.

1871. "Lists of Birds collected or observed in the Wardha Valley and its vicinity near Chánda": Journ. As. Soc. Bengal, xl, pt. 2, pp. 268–277.

1871. "Notes on three New Birds from Sikkim (*Phylloscopus pallidipes*, *Pellorneum Mandellii*, *Propasser saturatus*": Proc. As. Soc. Bengal, pp. 215–216.

1871. "Note on the Plant-bearing Sandstones of the Godavery Valley, on the southern extension of rocks belonging to the Kamthi Group, to the neighbourhood of Ellore and Rájámandri, and on the possible occurrence of Coal in the same direction": Rec. Geol. Surv. India, iv, pp. 49–52, 82.

1871. "Report on the Progress and Results of Boring for Coal in the Godávarí Valley near Dúmágúdem and Bhadráchalam": Rec. Geol. Surv. India, iv, pp. 59–66.

1871. "Description of a New Himalayan Finch (*Procarduelis rubescens*)": Proc. Zool. Soc., pp. 693–695.

1871–2. "Account of a Visit to the Eastern and Northern Frontiers of Independent Sikkim, with Notes on the Zoology of the Alpine and Sub-Alpine Regions": Journ. As. Soc. Bengal, xl, pt. 2, pp. 367–420; xli, pt. 2, pp. 30–71; Proc. As. Soc. Bengal, 1871, pp. 167–170, 226–228.

1871-2. "Description of the Sandstones in the neighbourhood of the First Barrier on the Godávarí and in the country between the Godávarí and Ellore": Rec. Geol. Surv. India, iv, pp. 107-115; v, pp. 23-28.

1872. "Notes on a Collection of Birds from Sikkim" [1871]: Journ. As. Soc. Bengal, xli, pt. 2, pp. 152-170.

1872. "Monograph of Himalayan, Assamese, Burmese, and Cingalese *Clausiliæ*": Journ. As. Soc. Bengal, xli, pt. 2, pp. 199-206.

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PRELIMINARY ACCOUNT OF THE KANGRA EARTHQUAKE OF 4TH APRIL 1905. BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 14 and 15.)

CONTENTS.

1.—INTRODUCTION.

Brief outline of the shock: its great range and importance.

AFTER a lapse of only eight years since the great earthquake of 1897, India has again suffered a similar, though somewhat less intense calamity, in the disastrous shocks of the 4th of April last. Whilst that of 1897 originated in Assam and Northern Bengal, the starting-point of the present earthquake was the Kángra district of the N. W. Himālaya. Beginning at an early hour of the morning, when many people were still asleep, the more violent phases of the shock dealt summary destruction to life and property in the neighbourhood of the Kángra valley and Dharmsála; accomplished very great damage and caused considerable loss of life in the hilly tracts of Mandi State and Kulu; did serious damage to Dehra Dun, Mussoorie, Chakráta, and other towns in the vicinity; and slight damage to the large towns of Lahore, Amritsar, Jullundur, Sahåranpur, and others similarly placed with reference to the centre. Outside these points, again, in ever-widening closed curves, the earthquake was felt with continually diminishing intensity, until the limits of its appreciation by the unaided senses coincided roughly with part of an ellipse passing through the following localities:—Quetta, Surát, Ellichpur, False Point, and Lakhimpur. This curve, if continued, passes into the little-known and unreported-on regions of the higher Himālaya and Tibet; but it may be trusted to represent approximately the limit of sensible appreciability in that direction also, and to include a total area of about 1,625,000 square miles. Finally, outside these points (save for a few doubtful observations from isolated places) the record of the now greatly reduced vibrations is instrumental alone, but at the same time very complete. Not only did the seismological stations of India and the Far East—including those of Bombay, Kodaikanal, Calcutta, Batavia, New Zealand, and Japan—automatically register the earthquake, but so also did those of Europe and America, the records being unmistakably those of a very powerful shock. The earthquake must therefore be regarded as a notable one in the seismological history of the present and just concluded centuries, and, inasmuch as 20,000 human beings are estimated to have perished by it, it must also be ranked as one of the most disastrous of modern times.

Organization of its investigation.

Owing to the interruption of communications, it was not until the 6th of April that the full significance and magnitude of the shock became generally known in India, and steps could be taken by this Department for the proper scientific investigation of it. By that date, however, telegraphic warnings were issued by the Director of the Geological Survey to all District Engineers, Meteorological Observers, Telegraph Masters, Railway officials, and others, through their respective Departments, to record in writing the exact time and other details of the shock. These were followed by letters sent to the principal newspapers inviting volunteers all over India to answer a formulated set of questions, and to help in other ways by furnishing exact data. Question-forms were also printed, and in due course despatched, to all the provinces through the above channels, as well as to Political Officers and Residents of Native States. For the personal gathering of detailed observations of the effects of the earthquake in the more seriously disturbed tracts, the following officers of the Geological Survey were deputed: Mr. R. R. Simpson (followed later by Mr. K. A. K. Hallowes) to Dehra Dun, Mussoorie, and the neighbourhood lying S.-E. of Simla:

Mr. E. H. Pascoe to Lahore, Jullundur, and other large cities of the plains, and myself to the epicentral tracts of Kángra, Mandi, and Kulu, lying north-west of Simla. Mr. R. D. Oldham (late of the Geological Survey, and the compiler of the account of the Assam earthquake of 1897) has been asked to collect all information available from the extra-Indian instrumental records.

Basis of the present account.

The present account—which must only be considered as a preliminary one—has been compiled as quickly as possible on my return to head-quarters from the field. It, therefore, makes no pretensions to finality, except as regards the general features and effects of the shock. Besides expressing the results of my own field-work, it is based (1) on special reports sent in by my colleagues, Messrs. Simpson, Pascoe, and Hallowes; and (2) on the results of a necessarily brief examination of over a thousand earthquake-forms returned filled-in by official observers all over India, as well as by a considerable number of private individuals, to whom, collectively at present, the best thanks of the Department are here expressed for their generous response, which will be recorded in full detail in the final memoir. In addition to the above as sources of information, mention may be made of the principal newspapers of northern India, which spared no pains in reporting the earthquake in great detail, and whose early telegraphic accounts I found an excellent guide for prosecuting my own particular enquiries.

2.—GENERAL ACCOUNT OF THE SHOCK: ITS SUPERFICIAL ASPECTS.

Its suddenness.

All reports gathered from places near the earthquake centre agree as to the suddenness with which the great shock came, and the absence of anything of the nature of a crescendo. In this respect it presents a feature common to most earthquakes of the destructive class. To obtain a very connected account of its inception and progress from eye-witnesses in the more violently affected areas, has, however, been impossible—partly from the fact that many of those who would have been best fitted to speak were overwhelmed and lost their lives; partly because, on account of the early hour, many were still asleep, or only just preparing to rise; and partly because, out of those who escaped with their lives, so many were incapacitated by wounds, injuries or fright, that only a small minority remained who might have made useful observations had not they at once been fully occupied in aiding the wounded and rescuing those buried alive. The silent testimony of the long death-roll is, however, sufficiently convincing as to the rapid development of the shock, and the absence of any reasonably prolonged warnings conveyed by the preliminary tremors. In Kángra and the civil station of Dharmsála the proportion of killed to living is exceedingly high, and indicates a proportionately sudden attainment of the maximum vibrations. In Dharmsála cantonment the single-storied barracks and bazars were mostly evacuated just in time by the able-bodied, whereas double-storied buildings became either death-traps or scenes of extraordinary escapes. If one allows 3 seconds for the severity of the shock to awake and impress itself on any one situated in an upstairs room, 2 more seconds to prepare for flight, and 5 more to traverse rooms and passages and to descend a staircase to the means of exit, we might, I think from the evidence before us, limit the time for escape to, in all, about 10 seconds after the commencement of the earthquake. Many who were fortunately situated, or alone, probably accomplished this; but in a crowded double-storied barracks the outlets would become congested, and confusion cause further delay; whilst (as was certainly the case with households) the search for the various members, especially children, must have delayed the escape too long, and so the occupants were caught and overwhelmed by the falling débris. Of reliable witnesses whom I interviewed, no one of those living in upstairs rooms who must have extended the moments of grace beyond about 10 seconds were able to get clear of the house before the crash came; and their ultimate escape was due to their protection by the fortuitous falling of wood-work, beams, etc.

In other localities along the epicentral tract there is also a consensus of opinion as to the suddenness of the shock, whilst even at Lahore and the neighbouring cities of the alluvial plains it is described as jerky and abrupt, following on preliminary tremors to be reckoned in seconds only.

Preliminary tremors.

That there were preliminary tremors of very brief duration is, however, clear from the accounts of survivors in the Kángra valley and neighbourhood, as well as at more distant points. In some cases in Dharmsála these preliminary warnings are stated to have enabled persons to leave their dwellings just in time. Although 135 perished in the big Gurkha barracks, such tremors are nevertheless implied by the fact that scarcely any of them were found killed in their beds. One account from McLeodganj bazar states that these first effects were of the "nature of tremulous vibrations" and were likened to the "rustling of leaves in the wind." In Dehra Dun, also, minor preliminary vibrations are recorded which enabled those who were awake to reach the door. In Mussoorie, according to an eye-witness, preliminary tremors lasted from 15 to 20 seconds; and the same were noticed in Landour by several people. In Lahore preliminary shocks with intervals appear to have lasted for about 11 seconds before the arrival of the main shock.

The main shock.

Regarding the nature, duration, and direction of the main shock or shocks, there is considerable diversity of opinion expressed in the narratives of observers within the epicentral tract. This is probably due, not so much to personal bias, as to actually subsisting differences in the character of the shocks, especially so in widely-separated areas differently aligned with reference to the actual centre. A common description of the main destructive oscillatory movement applicable to the Kángra valley and Dharmsála, and based on such scanty information as is available, is that it consisted of a violent horizontal shock from north to south followed by an equally violent counter-shock from the opposite direction. A few observers noticed a third shock like a "downward sinking." There is preponderance of evidence in favour of the second shock being slightly the more violent, or at least the more destructive of the two, inasmuch as it was during it that "everything collapsed." The evidence is not clear as to the time intervening between the two shocks, but it seems to have been from one to four seconds. Sometimes the evidence appears to be distinctly contradictory, but it is highly probable, as already stated, that there were actual differences in often closely related localities. That these shocks really were brief and of powerful intensity, rather than long-continued and moderate. seems a generally correct deduction from the havoc wrought to many strongly and solidly-built structures, as well as from the testimony of survivors. The evidence from the former source will be considered later under a separate heading. As regards testimony, it seems certain that not only was it a physical impossibility at Dharmsála to keep one's feet whilst standing or walking, but also that people were "thrown to the ground." A similar violent effect is related at Pálampur, at least in double-storied buildings, whilst even as far away as Bajaura in Kulu, where the shock was considerably less intense, men clung to trees to steady themselves and some were sent "sprawling on all fours."

Kangra.

At Kángra the mortality was so terrible, especially among Europeans and officials, that no accounts have come to us through the usual channels—a sad fact which must be left to speak for itself as to the devastation wrought.

Dharmsala.

At Dharmsála cantonments Captain Muscroft first felt a tremor, called out to his companions, and escaped outside where he was "thrown to the ground as the house crashed down amidst the roar of the two shocks."[1] The Kotwáli bazar, Dharmsála civil hill, was shaken to pieces in a few seconds, tilted upwards, it is said, by the first shock, which ran down from the hills above, and then sent crashing to the ground by a second shock which came from the opposite direction almost instantaneously.[2] Mr. Naurojee Khujoorina (of Messrs. Framjee & Co.) was an eye-witness at McLeodganj bazar, Dharmsála civil hill, and he says that he rushed out at the first shock. He looked into the valley and saw native houses falling one after the other, and as the second shock came his house collapsed into a heap of ruins.[3] In his report to the Geological Survey the same observer describes three shocks, first a tremulous vibration with a minute's interval between it and the second shock. No sound was heard before, but a "rattling noise with a shrill high note" preceded the second shock. Captain C. Stansfeld, 7th Gurkha Rifles, in his report, describes two distinct shocks with 3 or 4 seconds' interval. The houses fell flat and not to any one direction, and he thinks without any oscillation. The first shock woke him, then a roar came from the north or north-east. He ran out of the house and was thrown to the ground south-east or east.

Palampur.

Mr. A. H. Machean, of Clachnacuddin Tea Estate, reports three shocks, the second longer and more violent than the first and from the north-east or east. The third seemed a sudden circular shock in which all the buildings collapsed, followed by a sudden jerk from north-east and back again.

Baijnath.

Mr. F. A. FitzGerald, of the Baijnáth Tea Estate, was standing before a window open towards the south, when, preceded by a terrific roar, the house began to shake.

[1] *Pioneer* of 17th April 1905.

[2] *Civil and Miltary Gazette* of 16th April 1905.

[3] *Pioneer* of 19th April 1905.

He rushed outside with difficulty. The shock appeared to come from south to north beginning with a tremulous vibration, which increased in intensity until he was nearly thrown off his feet. His houses partially collapsed, trees swayed to within a few feet of the ground, birds rose from the trees with deafening shrieks and a cat and dog ran away terrified.

Summing up the meagre narrative evidence for the main shock in the Kángra valley and Dharmsála neighbourhood, the following characteristics are plainly established :—

(1) The sound was a roar or crash.

(2) There were two or three violent shocks.

(3) People were thrown to the ground.

(4) Buildings fell almost instantaneously into utter ruin.

(5) There was very great mortality.

Mandi and Kulu.

In the less violently affected parts of Mandi State and in Kulu, where everything points to a greater depth of the focus, the evidence is still scanty, owing largely to the fewer inhabitants and the absence of large towns and military stations. Fortunately, we have been supplied with detailed accounts by Colonel R. H. F. Rennick (Indian Army, retired), and General Osborn, both residents of the Kulu valley, and present at Bajaura on the morning of the earthquake. Neither of these observers record a distinct breaking up of the main movement into separate shocks. General Osborn states that the brief preliminary tremor increased with a regular accelerating motion till it reached its climax of greatest violence, remained at that for a few seconds, and then diminished and died away as it had begun. Colonel Rennick was awakened by the approach of an underground sound of the nature of a dull rolling noise, which became a roar like a bombardment when the main shock was established. Both observers place the direction of the vibration as approximately north and south, but whereas General Osborn puts the duration at 1½ minutes, Colonel Rennick estimates it at fully 5 minutes. The former also thought the vibration a fairly regular to-and-fro motion, whereas the latter observed a vertical component in the shock, which made the house and other things dance like "peas on a drum." Considerable damage was done to buildings, the upper stories of even well-built houses being partially wrecked. The loss of life was also great. Landslips and earth-fissures were a prominent feature as is natural in a country of steeply-carved mountain-slopes and precipices. These will be referred to again later. Captain A. T. Banon's account of the effects in the Upper Kulu Valley agrees substantially with the above. In a second letter, dated 6th May, he gives some further interesting details of the earthquake effects in the higher valleys north of the Dhauladhar range.

Summing up, we have for Kulu:—

(1) A dull, rolling noise which became a roar.

(2) The shock was a single, continuous vibration, increasing and diminishing regularly.

(3) People had to cling to trees for support, or were sent sprawling.

(4) Buildings show considerable damage, amounting to ruin in some cases.

(5) There was considerable mortality.

Dehra Dun-Mussoorie area.

In Dehra Dun, Mussoorie, and the neighbourhood the chief vibrations appear to have been horizontal, and to be once more divisible into two or three main shocks, or maxima of oscillation, accompanied by a rocking motion causing trees to sway, and sufficient to disturb the balance of people standing or walking. Estimates of duration vary from 15 seconds to 2 minutes. A positive bit of exact information is afforded by Colonel S. B. Burrard, R.E., F.R.S., Superintendent, Trigonometrical Survey, at Dehra Dun, who considered that the horizontal vibrations had a frequency of 3 per second, as also by Lieutenant H. W. Kettlewell of Landour, who estimated them at 4 horizontal vibrations per second. Some observers at Mussoorie noted 3 distinct shocks with intervals of 2 or 3 seconds. The earthquake sound was a moaning, rushing, rumbling or rattling noise, just before and accompanying the shocks. The direction was north and south or N. E.—S. W. There can be no doubt from the recorded sensations of observers, as well as from the evidence of damage to buildings, that the intensity of the earthquake was generally less at these places than in the greater part of Kulu or in the Kángra valley.

Summing up for the Dehra Dun-Mussoorie area we have:—

(1) Moaning, rushing and rattling sounds.

(2) There were two or three discontinuous shocks.

(3) People standing or walking lost their balance.

(4) Buildings show serious damage, chiefly fissures and cracks.

(5) Loss of life insignificant.

Lahore and other cities of the plains.

At Lahore, Amritsar, Jullundur, Sahâranpur, Rurki, and other cities on the alluvial plains, where the energy of the earthquake had already been so greatly reduced by diffusion, that the fall of even parts of high and unstable buildings was a rare occurrence, the shocks are still often described as jerky and abrupt, and as causing considerable alarm. There were two or three distinct shocks, the second (where two are mentioned) being the stronger. Rumbling sounds were generally heard, but they are not recorded from Lahore. There was no difficulty in standing with feet wide apart. Trees rustled as in a strong breeze, and books and light articles as well as cupolas from towers were projected from their supports. The direction of the shocks was either very complex or else there was more than one distant source of them.

More distant effects of the shock.

Outside the limits just indicated, the progress of the shock must for the present be followed in very brief outline. The sound phenomena gradually die away; damage to buildings and even cracks in walls cease; the effects become limited to shaking of bedsteads, rattling of doors and roofs, with the swinging of light articles, especially clothes suspended from pegs.

Next come very great areas where the shock, although felt distinctly, was a mere vibration; beyond that, again, others where it was scarcely felt at all, and where the evidence for the shock is very largely made up of observations of the movements of water in reservoirs.

3.—THE ISOSEISMALS.

Maps.

The accompanying two maps will show the disposition of the few isoseismals, or curves of approximately equal surface intensity, which it is considered prudent to insert in this preliminary account. In the full report, when all the earthquake forms and other sources of information have been estimated, it is hoped that the intervening lines may be added. Notwithstanding their present deficiencies, the curves express much of a very interesting nature, which it is the object of this section to roughly outline.

Scale of intensity used.

In drawing these curves the Rossi-Forel scale of intensity has been used, with the exception that isoseismals 1 and 2 must necessarily be differently interpreted at the present day, when great earthquakes are recorded by seismographs all over the world. Prof. Omori's intensity scale for destructive earthquakes, on the other hand, though very complete in the higher grades, allows place for two more isoseismals of still greater degrees of intensity than the Rossi-Forel No. 10. These latter were framed by their author to include surface intensities sufficient to destroy large iron bridges and railway lines, to shatter and convulse low cultivated lands, causing trees and vegetables to die, and to produce fault scarps at the surface—a degree of surface intensity not reached by the present earthquake. On this account, and because the lower isoseismals are less complete in Omori's than in the Rossi-Forel scale, the latter has been found more useful in the present instance. Only the outermost curve, No. 1, representing the limits of human sensibility, and the innermost four isoseismals, Nos. 7, 8, 9, and 10, representing the highest intensities, are here given, that of greatest intensity, No. 10, appearing to fit the position assigned to it fairly accurately.

Isoseismal No. 10.

The area of maximum intensity included within isoseismal 10 is roughly bounded by Dharmsála, Rehlu, Daulatpur, Bawarna, and Pálampur; and it includes of course the important town of Kángra, besides some smaller towns and hamlets. The size of the area is about 200 square miles; but on the east-south-east it fades away very gradually into the area of next intensity. With few exceptions, all or practically all buildings were found to be destroyed within this area; only the very strong, *e.g.*, the Dharmsála magazine and treasury, and a few pliable wooden structures and low huts escaping. Bazars such as those at Kángra and the Kotwáli bazar at Dharmsála, built mostly of sun-dried bricks and with slate or thatch roofs, were literally levelled to the ground. Many of the smaller scattered bazars of Dharmsála, Bawarna, Pálampur, etc., were nearly so levelled, and the same is true for the hamlets dotted about at intervening points. During my tour through area 10 of the epicentral tract, nothing impressed me so much in the valley area as the contrast between the expanse of ripening wheat fields, the trim tea-gardens, the well-kept roads, the avenues of trees and occasional wooded patches—all untouched by the earthquake—and the utter desolation presented by the mounds and rubbish heaps that alone marked the sites of former villages and towns. This contrast clearly indicates:—

(*a*) That the shock was of very great violence at the surface.

(*b*) That it was not, however, cataclysmic, thus giving a fairly precise upper limit for the surface energy over the area of greatest destruction.

Besides the usual roughly-built bazars and villages, the following were also ruined and mostly wrecked:—

(1) The stronger and massively-built temples of considerable antiquity, *e.g.*, the Golden Temple and others at Kángra, besides many small overturned temples and shrines.
(2) The ancient massive fort at Rehlu.
(3) Solidly-built court houses, police stations, jails, and barracks.
(4) Tea factories with their heavy machinery.
(5) Mission houses, and the English churches at Dharmsála and Pálampur.
(6) Many bungalows of various designs and strength.

Of all these, the roofs, towers, and generally all the walls were demolished, or with here and there mere remnants left. The degree of destruction to such solid masonry buildings was perhaps not so extreme as at Shillong during the 1897 quake—where scarcely a stone was left in position; but still it represents complete ruin with no alternative but entire rebuilding. There were, however, one or two notable exceptions in the hilly parts of Dharmsála: a particularly well-built bungalow, a few of the Gurkha lines, a portion of a bazar—all sheltered in hollows or bays along the hill-side—having marvellously escaped, sometimes without even a pane of glass being broken.

The damage to hill-sides by fissuring and slips is reserved for description to a section to follow, as such damage depends far more on the rock-structure and angle of slope, than on the actual intensity of the shock.

Isoseismal No. 9.

The next isoseismal, No. 9 of the scale, embraces the much larger area of about 1,600 square miles, surrounding No. 10 in a rough ellipse. The greater part of this area lies to the east-south-east of the 10 area with only a comparatively narrow band continuing round the north-west part of that area. On the west and south this isoseismal can be located with considerable accuracy as it cuts Sháhpur, Ránital, and Sujánpur; but further east-south-east by Mandi and Manglaur it is less well defined, the destructive effects within it dying away very gradually in that direction just as was the case within isoseismal 10. Its northern course also is somewhat vague where it cuts the uninhabited and little-trodden snowy ridge of the

Dhauladhár, passing thence to the Beas valley between Sultánpur and Naggar.

The destructive intensity within this area was found to vary considerably, but as regards the number of houses destroyed it averages about one-half. The western part of the area is geographically continuous with the area within No. 10, and it possesses a similar style of village architecture. To the east-south-east, however, the Kángra valley proper comes to an end, and a few parallel and lofty hill-ranges sweep round from the north, through which two chief passes, the Bubu and Dulchi, over 8,000 and 6,000 feet respectively, give entrance to the Kulu valley with its imposing and varied mountain scenery, its bazars built in many styles, and the quaint timber-bonded houses of the hill-people. Throughout this area the only approach to a constant type of building able to be used as a rough intensity measure, is to be found in the road-inspection and travellers' bungalows, which occur at regular stages along the various routes. These buildings were in most cases badly rent and broken, but not often entirely ruined, as were all buildings in area 10. They were, however, completely uninhabitable, and demanded reconstruction amounting nearly to entire rebuilding.

From the large portions still standing, the towns of Baijnáth, Guma, Mandi, Sultánpur, Bajaura, etc., were seen to compare favourably with the devastation wrought within isoseismal 10; but individually these towns show so many and such various stages of destruction according to purely local conditions, that their further description must be held over until the full report is written. Most of the small solidly stone-built Hindu temples within this area at Mandi, Baijnáth, Bajaura, Kulu, etc., successfully withstood the earthquake, as compared with those of area 10 which have mainly fallen.

The more steeply mountainous country beginning east of the Dhelu-Mandi road, and extending throughout the rest of this area, has given rise to many landslips, which severely damaged road communication and caused the Lárji lakes. They will be mentioned again later.

Isoseismal No. 8.

The next isoseismal, No. 8, may be split into two detached parts. The greater of these elliptically surrounds the ·9 area, and in its southern curve cuts Telokenáth (Mangla Devi) near Kotluh, a point between Dera Gopipur and Jawálamukhi, Suket, and Rámpur; whilst in its northern curve it cuts less definitely a point between Naggar and Manáli, another a little east of Manikarn and a third at Gaora near Rámpur. Its area is about 2,150 square miles. The lesser part of the isoseismal embraces a small detached area of about 1,200 square miles including Mussoorie, Landour, and Dehra Dun, and takes an elliptical form with long axis parallel to the greater ellipse. The evidence for this separation and parallelism is considerably strong, being based on the reports of Messrs. Simpson and Hallowes in the Dehra-Mussoorie area, combined with local reports from other outside places along the same axis, namely, the Chor mountain, Náhan, Tiri, Srinagar (in Garhwál), Ránikhet, and Almora. It is only fair, however, to say that one strip of intervening ground between it and the Rámpur end of the greater area has not been examined and no local reports have been received from it. At the same time any connection that way seems to me highly improbable, and could it be proved by surface indications would even then be difficult of explanation.

The damage to buildings within these two ellipses was found to be still sufficiently pronounced to be apparent at a glance. In the northern area it took the form of a roof gone here, the end house of a row there, a hill-tower bulged or partially shattered, and so on. But there is no doubt that the intensity has become greatly weakened, especially near the boundary line. The road bungalows were found to be partially habitable, and obviously repairable without entire reconstruction. The accounts of Messrs. Simpson and Hallowes with regard to the area within the southern ellipse, indicate about the same grade of intensity, and are well illustrated by the record of damage to buildings at Dehra Dun, Mussoorie, Landour, etc. There, badly built and unstable structures have been seriously shattered, verandahs and house corners are out of plumb or partially shot away, cracks, amounting sometimes to rents and fissures, pervade most brick and stone buildings, and have sometimes necessitated extensive repairs and partial rebuilding.

From Chakráta accounts implying a similar or slightly inferior degree of damage have been received.

Isoseismal No. 7.

As just mentioned, the 8th isoseismal is coincident with a great, and universally marked, rapid decline in the visible intensity as expressed in house damage, so that on entering on the very large area circumscribed by isoseismal No. 7, we are manifestly getting away from the epicentral regions altogether, and into a tract where the power of the earthquake to carry destruction with it had very nearly ceased. Up to isoseismal

No. 8, the effects of the earthquake were found to be everywhere sufficiently dominant to command general attention. Beyond it the villages and towns presented an ordinary everyday appearance, and it was only on investigating things closely, by overhauling individual houses, that cracks, generally of small account, falls of plaster and of unstable light articles were still to be found subsisting. Nevertheless, the great alluvial plains away from the hills, and especially the larger towns and cities, undoubtedly did evince a slight amount of easily apparent damage that might at first sight be imputed to a slightly increased intensity in this direction. As instances may be cited the serious damage to the Town Hall, Railway Station, and market in Lahore; the practical universality of cracks in bungalows in Jullundur, the twisted and broken clock-tower at Amritsar, and the earth-fissures at Rurki. It seems probable, however, that the natural intensity at these localities has been really augmented in the above instances by the nature of the alluvial bed. It should also be remembered that very large towns such as Lahore, with their numerous and diverse architectural subjects, give a greater range for the law of probabilities to furnish us with some few remarkable effects.

The isoseismal surrounding the above area has been drawn passing slightly to the south of Jamu, cutting Sialkote and Lahore, passing between Jullundur and Ludhiána, and thence curving round by Muzuffarnagar and Bijnor. Its course on the north-east side of the epicentral tract is altogether problematical. It may be said to include an area of about 36,000 square miles where damage to buildings in the form of small cracks is very slight as a rule, sometimes almost entirely absent, and only very occasionally destructive. But in the terms of the Rossi-Forel scale, it nevertheless represents a degree of intensity sufficient to have caused general panic, coupled with overthrow of moveable objects. In using the above expressions it must be understood that percentages of damage and not actuals are meant. Now that our isoseismals are so large, and the affected area so immense, a very small percentage of destruction aggregates a great deal.

The remaining isoseismals.

The systematic description of the lower isoseismals will not be continued further in this short paper, because their delineation no longer depends on personal observation, but on the comparative estimation of a large number of individually recorded impressions furnished by the earthquake forms.

4.—THE ISOSEISMALS IN RELATION TO THE FOCUS.

Nature of the Focus.

Taking the isoseismals so far described in one general and comprehensive view, some noteworthy peculiarities may now be tabulated concerning them, and their bearing on the nature of the focus pointed out.

We may note:-

(1) The elongated epicentral tract enclosed within the last 3 isoseismals of highest intensity in the Kángra-Kulu area.

(2) The close approximation of their curves at the west-north-west end of that tract.

(3) Their widely-separated positions in an opposite direction, *viz.*, east-south-east.

(4) The small, isolated ellipse forming the southern part of isoseismal No. 8 in its course round the Mussoorie area.

With regard to (1) the elongated form of the Kángra-Kulu epicentral tract, it seems certainly to indicate that the original earthquake impulse proceeded from a centrum of the nature of a line or plane following beneath this longitudinally extended tract.

With regard to (2), it should be remarked that in travelling from Nurpur to Kángra, and from Haripur or Dera-Gopipur to Kángra, we cross in each instance through the grades of intensities from such as are marked by trivial cracks in the plaster and corners of walls to those of complete destruction to buildings, and all within the short radial distance of 8 or 9 miles. In other words, the surface intensity increases extremely rapidly in these directions and indicates a proportionately shallow depth for the position of the centrum in the vicinity.

With regard to (3)—which briefly expresses the fact that in travelling from the Kángra neighbourhood across the same isoseismals but in an east-south-east direction we must cover about 100 miles of continuous and slightly diminishing intensity—an exactly opposite conclusion is indicated, namely, the increasing depth of the centrum in that direction.

With regard to (4), the conditions imply a smaller separate centrum, following an axis parallel to that of the Kángra-Kulu area, once more rather nearer the surface, and of an actual focal intensity much less than that at the Kángra-Kulu centrum.

For the present we must be content to regard these two axial lines, lying within planes (probably of faulting), as being the main and subsidiary loci either of one universal and contemporaneous shock, or of two, or even a series, of separate but almost instantaneous shocks, following one another sympathetically along lines of great tension.

Depth of the focus.

In the earlier days of seismology, when the focus or centrum of an earthquake shock was conceived of as approximately a point from which one kind of elastic vibrations proceeded in a perfectly radial manner, a great deal of attention was bestowed on overthrown objects and on the direction and angles made by planes of fissuring in buildings, that is to say, the earthquake was treated as more ideal in its simplicity than has subsequently been shown to be the rule. In the present instance also, a large amount of data of the above kind has been laboriously accumulated on the chance that it might all tend to the localisation of a fixed centrum at a given depth. As it has turned out, the above data have generally given no uniformity of result, either as regards direction or depth. Very locally some of them point approximately to the nearest seat of disturbance; but taken as a whole they can only be interpreted in one of two ways. They must either be considered entirely untrustworthy owing to the secondary effects of different rocks, rock structures, and soils on the passage of the waves, or their diverse indications must be taken literally as pointing to innumerable foci having varying positions and depths. One other interpretation, which is a blending of the two previous ones, is to consider that the facts imply a complication of centra, or points of maximum impulse, distributed along a line of the kind found probable from a study of the isoseismal chart. This being so, we are once more driven to make use of the above chart as our chief guide in searching for further and more quantitative details about the exact position and depth of the originating disturbance. The method adopted by Major C. E. Dutton [1] recommends itself here by its reasonableness and general applicability.

On the assumption of a uniform medium, and that the intensity varies inversely as the square of the distance from the origin, Dutton shows that the variation of *surface* intensity along a horizontal line drawn from the epicentre is most rapid at a particular point which depends on the depth of the focus only, a point also where the intensity must be $\frac{3}{4}$ of the maximum intensity at the epicentre. The relation

[1] "Earthquakes in the light of the New Seismology," Chap. IX (1904).

between the two is exhibited by the formula $x = q \tan 30°$, where x is the horizontal distance of the place from the epicentre, and q the depth of the focus. If x is known, then $q = x\sqrt{3}$. In the diagram, fig. 1, A B represents the surface of the ground, O the centrum, and the vertical lines are proportional to the intensities at the several points on A B. The resulting curve is steepest at the point where it touches the ¾ intensity line.

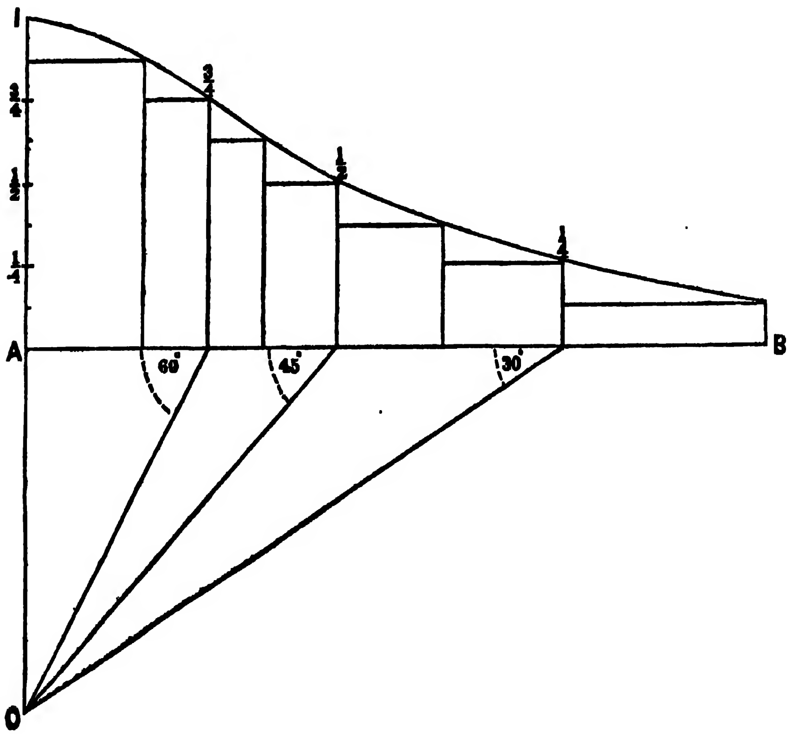

FIG. 1.

Now, it seems that we may apply this formula to the present earthquake by making sections across the epicentral tract at right angles to its long axis. The only difficulty is the recognising of that portion of the cross-section where the intensity declines or varies most rapidly. With regard to the Kángra end of the northern epicentral tract, there is no difficulty, as has already been shown, in making a selection of points situated near its W.N.W. end which must be correct within a few miles. From those points the distance to the epicentral line cannot be less than 7 or more than 12 miles. The centre, therefore, between Kángra and Dharmsála must lie at some depth greater than $7\sqrt{3}$ and less than $12\sqrt{3}$ miles, *i.e.*, between about 12 and 21 miles. Taking another cross-section over the tract from Naggar through Sultánpur, Mandi, and Suket, the horizontal measurements, though less exact, cannot be less than 12 or greater than 24 miles, and therefore the depth must lie between $12\sqrt{3}$ and $24\sqrt{3}$, or between 21 and 40 miles. The centrum thus deduced for this part of the earthquake-area can, therefore, be represented by a line or axis running from a point about midway between Kángra and Dharmsála in an E.S.E. direction towards Bajaura, a distance horizontally of 50 miles and at a depth of from $>12<24$ to $>21<40$ miles, the average being from 18 to about 30 miles, with a dip or pitch of 13½ degrees with the horizontal.

It will no doubt be thought by many that the above depths are possibly exaggerated, and in any case there is no doubt about their vagueness. Whilst freely admitting the possibility of serious refraction caused by change of rock-formation through which the shock must have been propagated, there are two general facts which point to at least a *considerable* depth for the part of the centrum below the Kulu area. One is the extremely large area over which the shock has undoubtedly been felt, and the other the only moderate violence at the surface. In other words, a shock of intensity 8 at the surface at Kulu, if of shallow origin, would not have been so powerful at that origin as to have been felt in such remote parts as the Bombay Presidency and Assam, nor would one of intensity 10 at Kángra unless it also were proportionately deep-seated.

With regard to the smaller subsidiary focus for the isolated Dehra-Mussoorie area, the fact that the latter is delineated by only one isoseismal, which has only been crossed by my colleagues at one point on its southern limb, and at a time when its isolation from the Kángra-Kulu epicentral tract was not suspected, renders impossible the application of Dutton's method of estimating the depth, inasmuch as there are no data for approximately determining the points of most rapid decline of intensity. On general grounds one would expect the depth of the centrum to be considerably less than at the Kulu end of the northern area.

5.—INTENSITY: ACCELERATION OF WAVE PARTICLE.

The foregoing isoseismal lines and their enclosed areas, it will be observed, have been mapped mainly according to the general effects produced by the earthquake on buildings. That no specific measurements have been made of the acceleration, amplitude, or period of the wave particle is a necessary misfortune in an area destitute of suitable seismographs. The common practice of drawing a certain amount of limiting values for these measurements from overthrown or projected natural bodies has also in this area had little scope, partly because of the general absence of suitable objects, and partly because of the extreme complexity of such cases as have occurred. The same causes which have tended to obscure the conclusions to be drawn from the direction of objects overthrown have also confused those deducible from the amount of that overthrow. For the present, I propose to mention only the following selected cases as evidence in this connection, because they appear to be less open to objections on the score of complexity than any others.

The old European cemetery at Kángra Bháwan lies in the middle of a flat plain, and at the time of my visit exposed a number of rectangular masonry pillars, overturned or broken with more regularity of direction than I have seen elsewhere (see fig. 2.) They comprise :—

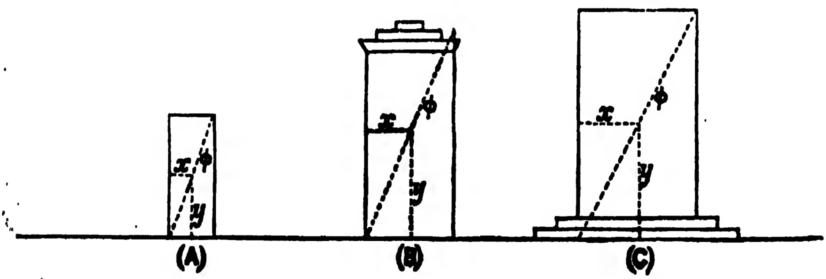

FIG. 2.

(A) Two small, rectangular upright tombs, 3 ft. high, by $1\frac{1}{8}$ ft. square. Fallen as a whole towards N.E.

(B) A pair of gate-pillars, of dressed stone and lime-mortar outside, with rubble within, 5 ft. high by $2\frac{1}{12}$ ft. square. Fallen as a whole, one towards E.25°N. and one towards W.20°S. (*i.e.*, nearly in opposite directions).

(C) A pair of pillar-like tombs, constructed like the gate-pillars, $5\frac{1}{2}$ ft. high by $3\frac{1}{3}$ ft. square. Not upset as a whole, but shattered above the base into fragments.

Using West's simplified formula for determining the acceleration of the wave particle, a formula which has stood the test of much experimental proof, we have :—

$$f = g\frac{x}{y}$$

where x = half diameter of the base and y = the height of the centre of gravity.

Then, in the three cases above, we have as follows :—

For (A) f =	>	$11\frac{2}{3}$	ft. per sec. per sec.
For (B) f =	about	13	„ „ „
For (C) f =	<	19	„ „ „

Since in the case of (A) both bodies were upset towards the direction of shock, and in the case of (B) one towards and one away from that direction, whilst in the case of (C) they were not upset at all, we may deduce a rate certainly between $11\frac{2}{3}$ and 19, and probably near 13 ft. per sec. per sec. for the acceleration of the wave particle at Kángra.

But, according to Prof. Omori,[1] the formula :—

$$2a = \frac{4x\,(x^2+y^2)}{3y^2}$$

where $2a$ is the double amplitude or range of motion of the overturning edge, will yield a limiting value for the amplitude of the earth vibrations in the case of short periods where the pillar is overturned towards the direction of impulse. Using it we obtain the result,

$$a = 9\tfrac{3}{4} \text{ inches,}$$

an amplitude which is large, but not excessive in the case of soft ground near the epicentre of a great earthquake.

Using this value for a in the general formula :—

$$f = \frac{4\pi^2 a}{t^2} = \frac{v^2}{a}$$

where t is the period of the wave and v the maximum velocity of the earth particle, we can obtain values of t and v. We thus have altogether :—

Acceleration	f =	13 ft. per sec. per sec.
Amplitude	a =	$9\frac{3}{4}$ inches.
Velocity	v =	$3\frac{1}{4}$ ft. per second.
Period	t =	$1\frac{4}{7}$ seconds.

On the other hand, by using Prof. Omori's second formula for the case of a pillar overturned in the forward direction when the period of motion is comparatively long, and applying it to the second of the pair of gate-pillars overturned away from the direction of shock, we get :—

$$v = \sqrt{\frac{8gy\,(1-\cos\phi)}{3\cos^2\phi}}$$

[1] *Seismological Journ. of Japan.* Vol. XVIII, p. 120, (1893).

where ϕ is the angle between a vertical side and the diagonal of the pillar. That is:—

$$v = 3.87 \text{ ft. per second,}$$

a value which is sufficiently near the one previously obtained by the other method to be corroborative of it.

6.—TIME OF THE EARTHQUAKE: RATE OF PROPAGATION.

A few selected observations.

The remarks made by Mr. R. D. Oldham in his memoir on the Assam earthquake of 1897[1] as to the varying standards of time in India, and the varying accuracy with which they are kept for ordinary purposes apply equally today. Without an exhaustive statistical treatment of all the returns sent in, the only way to arrive at an approximately correct result is to take a selected few of them, which *primâ facie* seem the most reliable. Fortunately, with seismographs of the Milne type installed at Bombay, Kodaikanal, and Calcutta, there is the less need to weigh a large body of doubtful evidence. These selected few mark a great advance on the records available in 1897.

Beginning of shock fixed at 6h. 9m. 0s. a.m.

From the Kángra-Kulu epicentral area it may at once be said that we have no accurate details, and indeed very few at all. From the Dehra-Mussoorie area the automatic records of the Survey of India instruments have furnished times, which, however, are still a matter of enquiry as regards details.[2] From Simla the time of arrival of the shock is given as 6h. 9m. 30s. A.M. (Madras time). From towns about the nearness of Sialkote, Lahore, Amritsar, and Jullundur there is a general body of testimony derived from well-regulated clocks giving 6h. 10m. 0s. as the time of arrival of the first big shock. From Rawalpindi and Saharunpur the time is 6h. 11m. 0s. So that from the above times we may reasonably conclude that at the chief epicentral tract the time was about 6h. 9m. 0s. within a second or two of error.

Arrival of large waves at Bombay, Kodaikanal, and Calcutta.

Skipping the intervening areas for the present in this account, there are available from the Government Observatory, Bombay (Colaba), a number of detailed automatically-recorded times (provisional and subject to future correction in detail), from which I naturally

[1] Mem. G. S. I., Vol. XXIX, Chap. IV, (1899).

[2] Later information received points to a discrepancy with the times here recorded. The subject will be discussed in the forthcoming full report.

select those furnished by the seismograph, it being the instrument best qualified for the purpose. Neglecting the preliminary tremors, and confining our attention to the large movements which are most easily distinguishable in the seismograms, we find they began about 4 minutes after the preliminary tremors, the latter being given as 6h. 13m. 1½s. Thus the time of arrival of the large movements at Colaba was about 6h. 17m. 0s. At Kodaikanal and Calcutta (Alipur) Government Observatories the seismographs recorded the same phase at 6h. 21m. 48s. and 6h. 17m. 0s. respectively.

Rate of transit of large waves.

Now, assuming that these large movements as registered on the seismogram films represent the first arrival of the large waves which travelled along the surface of the earth (a generally accepted conclusion) and that they began at 6h. 9m. 0s. at the epicentre, we can tabulate the following distances, periods of transit and rates, thus:—

PLACE.	Distance in miles from centre of large epicentre.	Seconds during transit.	Deduced rate in miles per second.
Bombay (Colaba)	950	480	1·98
Kodaikanal	1,497	768	1·95
Calcutta (Alipur)	950	480	1·98

Agrees with average for 1897-earthquake.

It so happens that Colaba and Alipur are exactly the same distance from the central point of the larger epicentral area, a point fixed by a personal survey of the devastated region; and the agreement in the time and consequent rate is extremely satisfactory, and it may be further noted to agree to the second place of decimals with the mean value arrived at by Mr. R. D. Oldham for the 1897 earthquake. The Kodaikanal time and deduced rate come sufficiently near to be in every way corroborative. If, neglecting the time at the epicentre, we take the difference of the Kodaikanal time and that of either Alipur or Colaba, and also the difference of their distances from the known epicentre, we get 547 miles in 288 seconds, or a rate of 1·90 miles per sec., a rate which, if applied through the whole distance, would give a time of 6h. 8m. 40s. for the beginning of the shock.

Clocks stopped in Calcutta.

Besides the above time of 6h. 17m. 0s. recorded at Calcutta, we have further corroborative times afforded by Mud Point and Saugor Island, which agree in giving 6h. 17m. 0s. Other time evidence in Calcutta that may be mentioned here has been derived from the stoppage of clocks. At St. Xavier's College the electric clock stopped at 6h. 20m. 0s.; at Alipur Observatory the astronomical clock stopped at 6h. 19m. 0s., but it is important to remember that so far from the centre as Calcutta, where the shock was necessarily very weak, it is probable that these clocks did not stop all at once, and therefore that they considerably overstate the time.

Rate of transit deduced by Omori from Japan seismographs.

Prof. Omori in his note on the present earthquake seismogram as registered at Tokyo[1] and other places in Japan, deduces a rate of 3·3 kilometers per second for the surface transmission—this rate being obtained by considering the times of arrival of the 3rd phase of the principal portion of the wave along the minor and major arcs respectively of the great circle joining Tokyo and Kángra; together with the time of re-arrival of the former after making one complete circuit of the Earth. The length of time for that complete circuit was 3h. 15m. 4s. The value 3·3 kilometers or 2·05 miles per second differs from the value 1·98 by only ·07 of a mile and may be considered as further corroborative evidence regarding the rate of transmission of the shock.

7.—FORE-SHOCKS AND AFTER-SHOCKS.

Ongole earthquake of 2nd April.

The usual large number of attendant after-shocks have succeeded the great shock of the 4th April, but their discussion will be reserved for the present. As to fore-shocks, there is no evidence that any were felt in the disturbed area. It may be mentioned, however—although the occurrence is probably only a coincidence—that on the 2nd April a considerable earthquake shock was felt at Ongole, Markapur (Kurnool district) and Madras, and that after-shocks of it continued up to and subsequent to the 4th April. On geological grounds there is no reason for regarding the connection in time as anything but accidental, and it is

[1] Appendix to Pub. Earthquake Invest. Com. in Foreign Languages, No. 25 Tokyo, 1905).

only mentioned here because of the importance of anything that might possibly bear on the matter.

8.—GEOLOGICAL CONDITIONS IN RELATION TO THE EARTHQUAKE.

(1) As causes.
(2) As effects.

On the now generally accepted theory that great earthquakes are due to strains set up in the earth's crust by geotectonic movements, and to their sudden relief by slipping along a fault, it is of importance to consider the geological structure of the area. Although one can hardly hope to identify the particular local structural accident that constituted the earthquake, the matter is of such gravity to mankind that any hopeful suggestions should be recorded. The above is one aspect of the bearing of geology on the earthquake. Another aspect is the superficial and secondary effects of the earthquake consequent on the nature and disposition of the rocks at the surface. Taking these two aspects of the subject in order, and premising that the subject is very complex, the suggestions which follow are made with a full recognition of their hypothetical nature.

Inbaying of Tertiaries in Kangra Valley and Dehra Dun.

Neither the accompanying maps, nor any that could be conveniently used for such a great area, do anything like justice to the topography of the main and subsidiary epicentral tracts, which really are of a very varied and characteristic relief according to their geological composition. However, if Mr. Medlicott's map[1], or even the general geological maps of India on smaller scales be consulted for an outline view of the geology, there will be noticed a striking structural peculiarity at these two points of the Himālayan area, namely, the great inbaying of the younger Tertiary formation of the Sub-Himālaya towards the higher central regions of the mountains. The line of the "main boundary" fault separating these Tertiaries from the very old Himālayan rocks of that region may be observed to take a huge sweep inwards and eastwards from the Rávi River to Drang, and then to return almost in a N.—S. sweep by Mandi, Suket, and Sabāthu, and round the foot of the Simla mountain spurs. The Tertiaries then pursue a normal direction until the Dehra Dun area is reached, when there occurs another, but much smaller, inbaying of them towards the central area. Nowhere else along the Himālayan mountain-foot, as we know it, is there such

[1] *Mem. G. S. I.*, Vol. III, 1864.

exceptional irregularity, unevenness one might say, in the disposition of these bordering bands of Tertiary strata (see fig. 3).

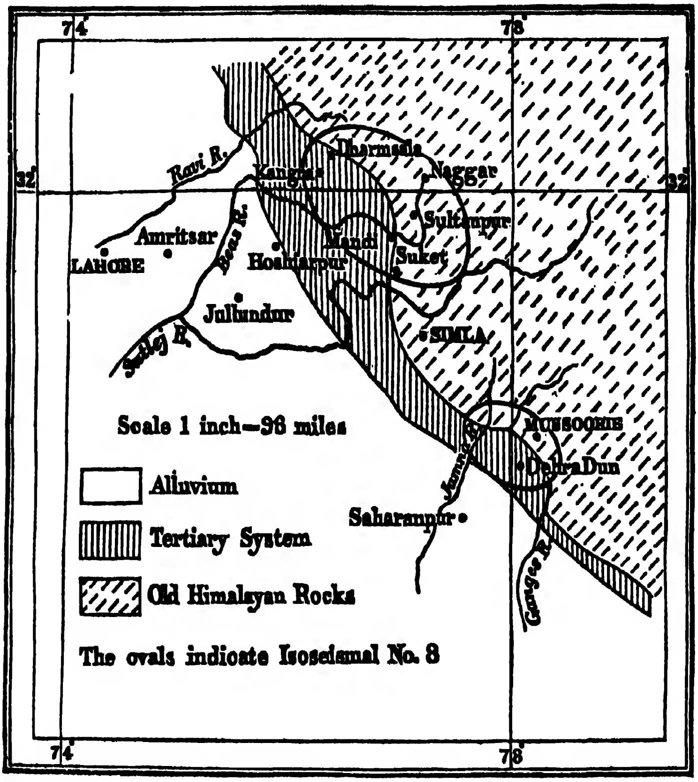

FIG. 3.

Now, the special function of all the folding and fold-faulting of the Sub-Himālayan tract that has gone on in Tertiary, post-Tertiary and possibly still more recent times has undoubtedly been to straighten out this mountain-foot into a very uniform curve—the great southwardly convex curve of the whole Himālayan chain. Therefore, areas which show any marked irregularities still left, such as those just pointed out, may well be in a peculiar condition of strain, extremely favourable to geotectonic movements, including faults.

It probably implies a condition of special strain.

This view is strengthened by the fact that already on the plainward edge of the Sub-Himālayan band considerable straightening has taken place, as is testified to by the long, straight strike-ridges behind Hoshiarpur and south-west of the Dehra Dun, respectively; whereas the areas in the angle of the inbayings show wavering irregularity of strike following the contours of the older Himālayan mass, succeeded by gently dipping areas forming longitudinal valleys, or, as at Dehra, the so-called "Dun."

Change of load by denudation and sedimentation.

Another source of such strain, and consequent tendency to movements, is undoubtedly provided by the steep slope from the Kángra valley at about 3,500 feet to the Dhauladhār ridge at about 16,000 feet, a horizontal distance of only 6 miles. With such a gradient the local interchange of load by denudation of the latter, coupled with deposition on the former, is inevitable; and that it has gone on for long ages is evident by the great debris fans and terraces of sand, clay, and enormous granite boulders that strew the valley-floor and also extend up the lower hill-spurs near Dharmsála. In a much less important degree the Dehra Dun presents some similar features.

It probably implies a further state of strain requiring re-adjustment.

From what we know of the isostasy of the earth's crust, especially along the Himālaya, such a continuously maintained change of loading cannot go on without re-adjustment. Such re-adjustment generally implies only folding and faulting with occasional insignificant earthquake shocks; but at the same time it carries with it the chance of a sudden change of strain enough to cause a great earthquake. As a matter of fact earthquakes in this area are said to be common, but generally non-destructive, whilst underground sounds of the nature of "Barisāl guns" have long been known.[1]

General instability of Himālayan Mountain-foot.

If the above structural peculiarities in the Kángra valley and Dehra Dun respectively, may be considered to have any influence in producing special lines of strain, then the major epicentre located at the former and the subsidiary epicentre at the latter place, carry out the same idea by possessing magnitudes proportional in size and intensity to the assumed causes. Should the particular local causes just outlined, however, be dismissed as fanciful, there can still be no doubt that the general tendency to instability of the Himālayan mountain-foot as a whole, consequent on rapid change of profile accompanied by

[1] Mentioned in a letter by Mr. C. Michie Smith, Government Astronomer, Madras. Mrs. W. S. Meyer, at "Townsend," Simla, about twelve days before the earthquake, also reports having heard rumbling sounds, not to be confounded with thunder, which the Meteorological Reporter to the Government of India reports as absent during the day on which the sounds were heard.

change of load, is an adequate cause in itself and one which is universally recognised by seismologists in all similar cases.

Geological conditions influencing surface-effects of the earthquake.

As to effects, that the earthquake, as felt disastrously and sensibly at the surface, was in many cases a very much modified product, depending largely on the nature of the stratified upper crust and on the surface-deposits, is abundantly clear for general and particular reasons. The subject is too vast, however, and also too full of unsolvable problems to do more than refer to it here very briefly. The following points are noteworthy:—

(1) All the surface valley deposits of alluvium, sand, gravel, and boulders appear to have been proportionately more heterogeneously shaken than solid rock.

(2) Of rock, the soft Tertiary sandstones have been thrown into more destructive vibrations than the older and more compacted strata.

(3) Narrow ridges with free ends (spurs) have been very much more shaken than broad areas and the flat hollows between the spurs.

(4) In the case of the more distant vibrations and tremors, the great alluvial tracts, and the flat-lying Vindhyans and Deccan trap with cotton-soil, have rendered such weak vibrations apparent, whilst the ancient and steeply-dipping Aravalis have resisted the shocks in a very noticeable way. As a consequence, there occurs an isolated area round about Udaipur, Dungarpur, Partábgarh, etc., from which no accounts of any shock have reached us. It is interesting to note that this area was similarly barren of results in the 1897 earthquake, although the shock was recorded both east and west of it.

9.—SPECIAL SURFACE-EFFECTS OF THE EARTHQUAKE.

(*a*) Earth-fissures: Rock and Land-slides.

Though serious all are of superficial origin.

In a short paper without illustrations it is difficult to convey a true impression of the size and importance of the secondary surface effects, relatively to the magnitudes (of mountain and valley) concerned. The danger of over- or under-stating is equally great. But it may at once be laid down that of all the ruptures of the hill-sides that have taken place with their accompaniments of rock-showers and soil-cap slides, none can be definitely regarded as having been caused by mass-movements of the solid rock from below upwards. Although the origin of the earthquake must be accepted without hesitation as due to just such a movement having taken place suddenly at a depth below the present surface, yet it nevertheless appears certain that the planes of such movement nowhere emerged at the actual surface of the ground producing changes of contour and drainage, or originating fault-cliffs, such as was a feature of the Assam earthquake of 1897 and the Japanese earthquake of 1891. The great majority, probably all, took place in a direction with gravity and not against it: all are secondary, and the expression simply of the shaking or vibrating of loose unstable material (whether in the form of soil, rock, crag or mountain-spur) followed by the descent of the disrupted masses to lower levels.

Chief causes are the crushed rock and steep hill-slopes.

Two causes have contributed to bring into special notice the rock and soil-cap slides in Kulu. One is the extremely fissile and sheared condition of the quartz-schists and epidiorites, which together with a considerable amount of much "mashed" limestone make up the principal rocks of the Kulu valley. The other is the extremely steep angle to which many of the slopes and precipices of the Beas river and its tributaries have been reduced by the continuous steady erosion of the river-bed. The Beas is much more gorge-like in its windings, especially near Lārji, than the majority of large rivers similarly situated in the Himālaya. It is no wonder, then, that when the earthquake came, such greatly splintered rock materials and such impending slopes—far above the limiting angles of safety—afforded ideal conditions for the production of landslips on a gigantic scale.

Kángra valley and neighbourhood.

A brief reference to actual examples must suffice here. In the immediate vicinity of Kángra and Dharmsála, where the hill-slopes are comparatively gentle for a mountainous district, though they steepen rapidly above Dharmsála, the appearance of fissures along many of the slopes, such as the Sessions House ridge at the former place, and the cantonment spur at Dharmsála, is a fair indication among other evidence of the greater intensity of the shock in that area. Special cases such as the narrowness of the ridge at McLeodganj bazar and at "Bryn," as also the peculiar lie and rock-composition of the Jail site (all on Dharmsála civil hill) have resulted in specially marked destruction, numberless fissures or, as at the Jail, an actual subsidence of the land in great blocks.

Palampur and Neogal gorge.

Above Pálampur, at the head of the Neogal gorge, one very noticeable rock-slide in the bare steep crystalline axis of the Dhauladhār range continued active for months after the earthquake. Each subsequent after-shock combined with the effects of melting snow dislodged further loose material, which, in its descent over precipices several thousand feet sheer into the bed of the gorge, gave rise to a dust-cloud of great volume that overtopped the great range and was visible for many miles away. It discoloured the snow-covered ridges far and near and was so continuous as to alarm the timid by its resemblance to a volcanic eruption. The nearer hill-spurs above Pálampur were also much damaged. In particular the fresh soil-cap, left whence snow had just retreated, showed that these slender ridges must have shaken like a quivering jelly and split up into fissures every few yards. Nearer Pālampur, again, and at other stream-outlets along the Dhauladhār, the shedding of the scarps of gravel terraces, and the skinning of the steep slopes carried away with them many miles of water-channels used for irrigating the lower parts of the Kángra valley.

Fojal Nullah.

A parallel instance to the Neogal Nullah dust-cloud is also afforded by the Fojal Nullah, about eight miles due west of Naggar in Kulu, where phenomena of the same kind, simulating volcanic action, took place, and where on the day of the earthquake the water joined the Beas river as a black torrent. Mr. W. H. Donald, Executive Engineer, Kulu, informs me that on the 24th May 1894 there was a previous rock-movement, or landslip, at the same place, accompanied by a flood and by a dust-cloud that continued for four months.

"Main-boundary" fault near Drang: Salt mines.

Near Guma and Drang the new cart-road from Pálampur to Mandi has been carried along the line of the main-boundary fault. The hill-sides for some way on both sides of the fault are much disfigured by cracks and landslips, but especially just along the junction, where not only are the rocks in that greatly-splintered and powdered condition usually presented in such places by the shearing and crushing that have gone on for geological ages, but also are rendered more unstable by reason of the local outcrops of easily soluble rock-salt. Much of the new road has been destroyed and many of the salt quarries blocked by rock-showers.

Dulchi and Bubu Passes.

The bridle-roads over the Dulchi and Bubu passes have also suffered in the same way, the latter, which enters a defile near the top, continuing blocked for many months.

Parbati River.

The Parbati river in Kulu, especially in its higher snow-fed tributaries, where precipices of white, much splintered quartz-schists abound, has been phenomenally prolific in rock-showers, which have often carried away with them pine forests as well as roads, and filled up the torrent-beds with streams of sliding debris.

Beas River at Larji.

At Larji, near where the confluence of the Beas with the Tirthan and Sainj streams takes place in profound gorges, the havoc wrought among the steeply-convex spurs is at first sight appalling. The Larji slips were still active when I was there, two months after the earthquake, and they showed signs of a probable great increase during the ensuing south-west monsoon. This river focus will indeed in my opinion give much trouble to communications for years to come.

Larji Lakes.

Both the Tirthan and the Sainj streams have been temporarily dammed up by the debris cones, some miles above Larji, forming lakes. The latter was still inaccessible when I was there, but I examined the Barwar lake, three miles up the Tirthan river. It is about three-fourths mile long in an S-shaped curve, and by reason of the rotten and much scarred precipices above, will be long before it attains a condition of rest. There seems to be no danger of the dam bursting, as a steady outflow had been established with a moderate gradient.

South-east of the Barwar lake damage to the hill-sides gradually diminishes. The northern ascent to the Jalori pass exhibits a few minor rock-slides and showers, and then there sets in comparative stability, especially in the wide open valley of the Sutlej near Luri. Near Mussoorie, however, a prominent rock-slide at the Kempte falls still shows the readiness of very steep slopes to give way under even the moderate shaking which this part of the area underwent.

(*b*) Miscellaneous Effects.

A common accompaniment of earthquakes is the disturbance of lines of natural water-springs. The usual form which this takes is an increase in the volume of water discharged: a result easily seen to be due to the surface-shaking of the rocks causing a loosening of the joints or other fissures along which the water escapes.

Springs.

The water-supply of Jawalamukhi, which has its source in springs, was about doubled; but the temple springs, with their natural inflammable gas, were not affected.

Jawalamukhi springs.

The boiling springs at Manikarn were slightly affected by the earthquake. One was checked altogether, and left a public bathing-place to run dry, whilst others within a short range shifted their channels. The character of the springs and their temperature (high enough to cook rice and other food-stuffs) remained unchanged.

Boiling springs at Manikarn.

Near Tipri, in the Parbati valley, a very small spring issuing from a rock-cleft flowed muddy for some months after the earthquake. Probably the continuance of after-shocks kept the water from clearing.

Spring at Tipri.

The springs at Mackinnon's Brewery, Mussoorie, increased their discharge by from 20 to 30 per cent.: a result accurately determined by Mr. Mackinnon. After 20th May the increase showed a gradual falling off until the end of June, when they resumed their normal flow.

At Mackinnon's Brewery.

The water in ordinary "tanks," or local reservoirs, was often visibly affected by the earthquake and thrown into waves or overflowed their edges, at localities where the shock was otherwise not felt. This was a common phenomenon round about Calcutta, at Ahmedabad, Bombay, and other places. In the case of tanks divided by partitions, the latter commonly burst. On many canals the water-wave due to the shock was also distinctly noted.

Reservoirs: Canals.

Many cases of so-called earthquake "shadows" seem to have occurred, whereby a house, village or bridge sheltered behind and below a violently agitated hill or gravel cliff were spared the shock, which had locally exhausted itself in visible disruption of the sheltering mass. As examples may

Earthquake "shadows."

be mentioned "Woodside," a house in Dharmsála cantonment; part of Forsythganj bazar; the Gurkha lines east of the Magazine, and those north of the upper parade ground; and many road-bridges in the epi-central tract. The numerous small hamlets immediately north of Dharmsála, and divided from it by a deep ravine or by a saddle in the hills, were probably partly protected by being in shadow, partly by being on firmer rock, and partly by reflection of the wave from the main boundary fault. Several small villages and shops lying on the lower north slopes of a hill of soft tertiary sandstone, one or two miles east-south-east of Baijnáth, were also protected, apparently by being in shadow.

Instances of the opposite effect—the very violent movement of long narrow ridges—are too numerous to mention. Every house-site in Dharmsála and other towns, desirable for its good position, drainage, and view, became a most undesirable site from the standpoint of the earthquake.

Movements of bubbles in level tubes.

From Sind and Burma the long drawn-out distant undulations of the earthquake affected the bubbles in level tubes during survey operations, the movement at the former place indicating a surface tilt of about 30 seconds of arc both above and below the horizontal, in a north-east—south-west direction. No sensible motion was felt at those places, and the gentle oscillations of the bubbles embodied all the local energy that remained of this powerful earthquake after its wide sweep across the half of India.

10.—GEOGRAPHICAL INDEX.

Places within Isoseismal No. 10.

Name of town or village.	District.	Lat. N.—Long E.	Distance in miles from nearest point of main epicentre.
Bawárna . . .	Kángra . .	32° 3′—76°33′	All within a few miles.
Chari	Do. . .	32°12′—76°19′	
Daulatpur . . .	Do. . .	32° 3′—76°19′	
Dharamsála . . .	Do. . .	32°13′—76°24′	
Kángra	Do. . .	32° 6′—76°19′	
Nagrota . . .	Do. . .	32° 7′—76°26′	
Pálampur . . .	Do. . .	32° 7′—76°36′	
Rehlu	Do. . .	32°13′—76°16′	

Places between Isoseismals Nos. 9 and 10.

Name of town or village.	District.	Lat. N.—Long E.	Distance in miles from nearest point of main epicentre.
Baijnáth	Kángra . .	32° 3′—76°42′	About 4
Bajaura . . .	Do. . .	31°51′—77°13′	„ 10
Barwar (lake) . . .	Mandi . .	31°42′—77°19′	„ 17
Bhuin	Kangra . .	31°53′—77°13′	„ 9
Bubu (pass) . . .	Do. . .	31°57′—77° 3′	„ 6
Dhelu	Mandi . .	32° 0′—76°51′	„ 4
Drang	Do. . .	31°49′—77° 1′	„ 4
Dulchi (pass) . . .	Do. . .	31°50′—77° 9′	„ 5
Guma	Do. . .	31°58′—76°55′	„ 4

Places between Isoseismals Nos. 9 and 10.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Jhatingri	Mandi . .	31°57′—76°57′	About 3
Kohad	Kángra . .	32° 5′—76°52′	" 9
Lárji . . .	Do. . .	31°44′—77°17′	" 14
Mandi	Mandi . .	31°42′—77° 0′	" 10
Paprola	Kángra . .	32° 3′—76°42′	" 4
Ránitál	Do. . .	32° 1′—76°18′	" 10
Sháhpur	Do. . .	32°12′—76°15′	" 8
Sujánpur . . .	Do. . .	31°50′—76°33′	" 14
Sultánpur . . .	Do. . .	31°57′—77°10′	" 10
Swar	Do. . .	32° 5′—76°55′	" 11

Places between Isoseismals Nos. 8 and 9.

(*1*) *In Kángra—Kulu Area.*

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Banjár	Kángra . .	31°38′—77°24′	About 24
Hamirpur . . .	Do. . .	31°41′—76°35′	" 22
Jalori (pass) . . .	Do. . .	31°32′—77°27′	" 30
Jari	Do. . .	32° 0′—77°18′	" 18
Jawalamukhi . . .	Do. . .	31°52′—76°23′	" 16
Jibhi	Do. . .	31°36′—77°25′	" 26
Kot	Do. . .	31°31′—77°29′	" 33
Manglaur . . .	Do. . .	31°40′—77°22′	" 21

Places between Isoseismals Nos. 8 and 9.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Manikarn . . .	Kángra . .	32° 2′—77°25′	About 24
Nadaun	Do. . .	31°47′—76°24′	„ 21
Naggar	Do. . .	32° 7′—77°14′	„ 20
Plách	Do. . .	31°39′—77°24′	„ 23
Suket	Suket . .	31°32′—76°58′	„ 22
Telokenath . . .	Kángra . .	32°14′—76° 8′	„ 14

(2) *In Dehra Dun-Mussoorie Area.*

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from epicentre.
Chakráta . . .	Dehra Dun .	30°43′—77°54′	All within a few miles.
Dehra Dun . . .	Do. .	30°19′—78° 5′	
Landour . . .	Do. . .	30°27′—78° 7′	
Mussoorie . . .	Do. . .	30°27′—78° 2′	
Rájpur	Do. . .	30°24′—78° 5′	

Places between Isoseismals Nos. 7 and 8.

Name of town or village.	District.	Lat. N.—Long. E.	Distance in miles from nearest point of main epicentre.
Amritsar . . .	Amritsar .	31°37′—74°58′	90
Bilaspur . . .	Simla States .	31°20′—76°49′	42
Chamba . . .	Chamba . .	32°29′—76°10′	29
Chawai	Kángra . .	31°27′—77°30′	33

Places between Isoseismals Nos. 7 and 8.

Name of town or village.	District.	Lat. N.—Long E.	Distance in miles from nearest point of main epicentre.
Chini	Bushahr . .	31°32′—78°19′	72
Dagshai	Simla . .	30°53′—77° 6′	67
Dalhousie . . .	Gurdaspur .	32°32′—76° 0′	35
Dera Gopipur . . .	Kángra . .	31°53′—76°16′	20
Gurdaspur . . .	Gurdaspur .	32° 3′—75°26′	53
Hardwar . . .	Sahāranpur .	29°57′—78°14′	144
Haripur	Kángra . .	32° 0′—76°13′	16
Hoshiarpur . . .	Hoshiarpur .	31°33′—75°58′	48
Jullundur . . .	Jullundur .	31°19′—75°38′	70
Kálka	Umbálla . .	30°50′—76°59′	70
Kapurthála . . .	Kapurthála .	31°24′—75°25′	77
Kasauli . . .	Umbálla . .	30°53′—77° 1′	65
Kotgarh	Simla States .	31°15′—77°34′	45
Lahore	Lahore . .	31°34′—74°21′	122
Luri	Simla States .	31°20′—77°29′	42
Mozuffarnagar . .	Mozuffarnagar .	29°28′—77°45′	170
Náhan	Sirmur . .	30°32′—77°21′	90
Najibabád . . .	Bijnor . .	29°37′—78°20′	170
Nurpur . . .	Kángra . .	32°18′—75°57′	26
Pathankot . . .	Do. . .	32°17′—75°42′	39
Pauri	Brt. Garhwál .	30° 9′—78°46′	141
Rurki	Sahāranpur .	29°53′—77°57′	144
Sabáthu	Simla States .	30°58′—77° 2′	61
Sahāranpur . . .	Sahāranpur .	29°58′—77°35′	129

Places between Isoseismals Nos. 7 and 8.

Name of town or village.	District.	Lat. N.—Long E.	Distance in miles from nearest point of main epicentre.
Sialkot	Sialkot . .	32°30′—74°34′	106
Simla	Simla . .	31° 6′—77°11′	58
Srinagar . . .	Brt. Garhwál .	30°13′—78°46′	147
Tarn Taran . . .	Amritsar . .	31°26′—74°54′	96
Tiri	Garhwál . .	30°22′—78°32′	128
Umbála	Umballa . .	30°21′—76°52′	102

G. I. C. P. O.—No. 653 D. G. Survey.—18-12-05.—700

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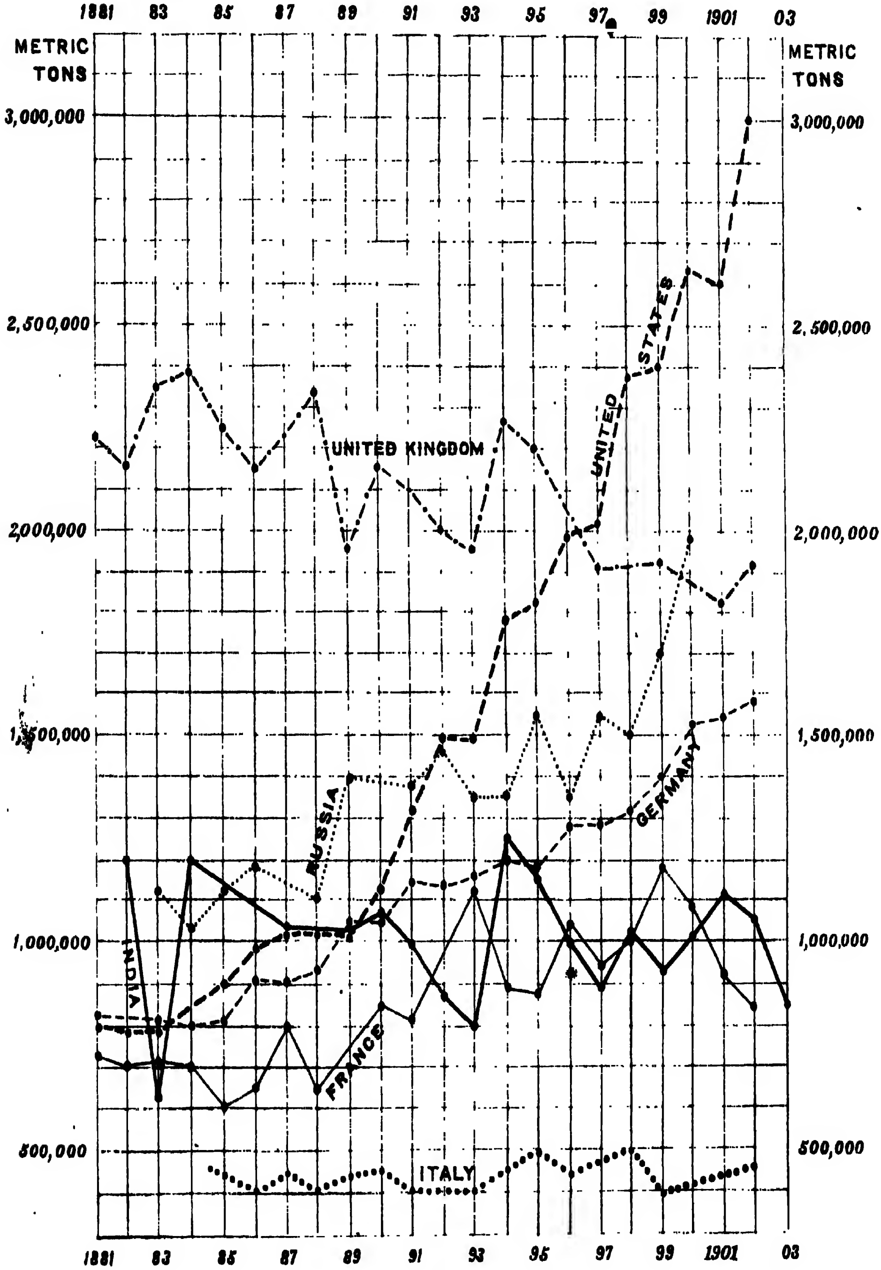
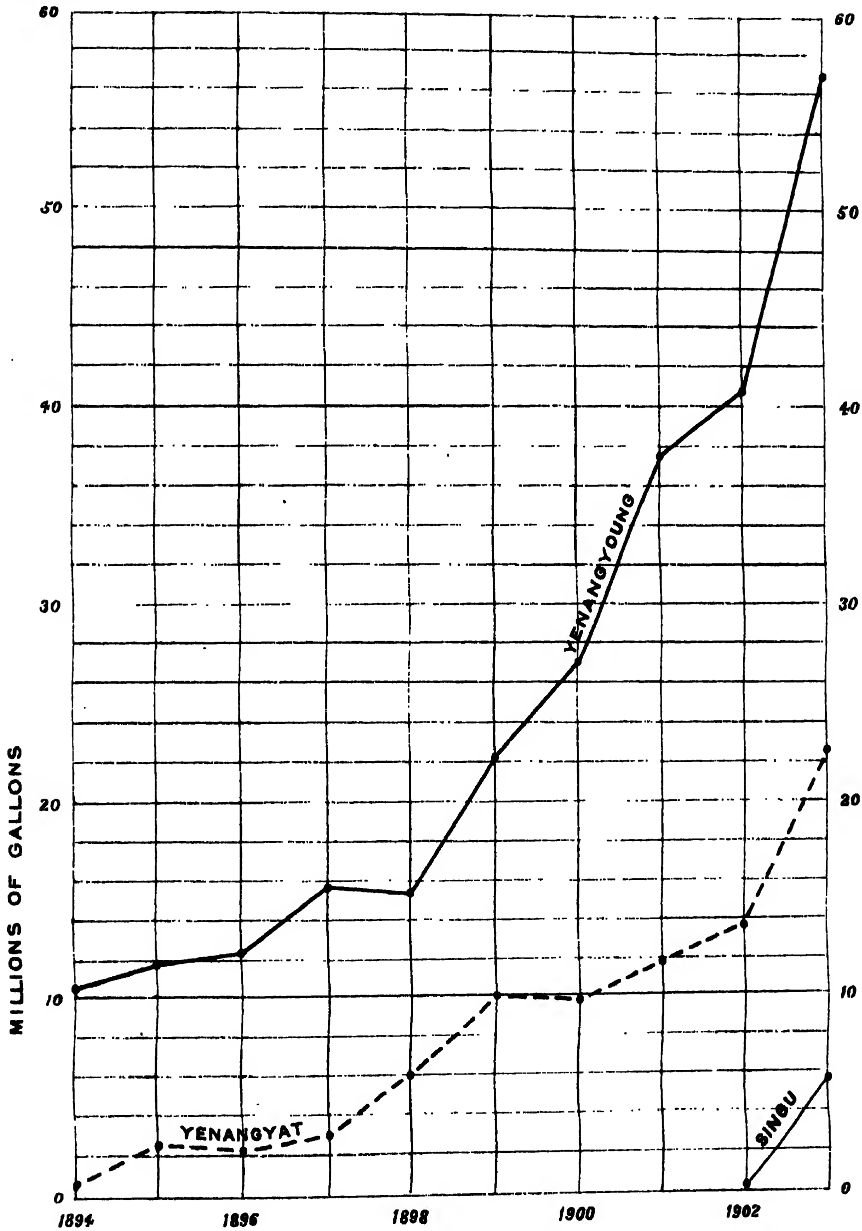
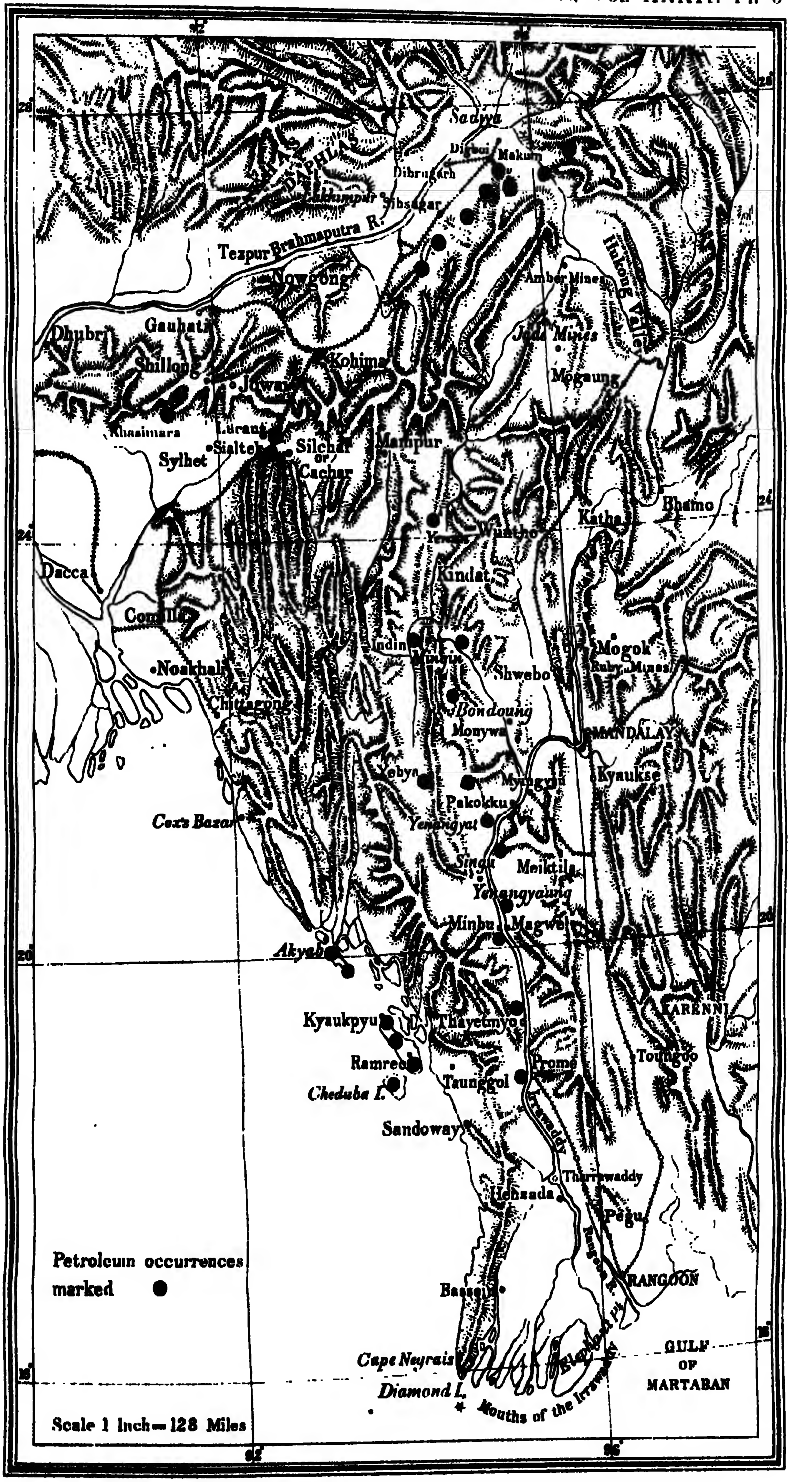


OUTPUT OF PRINCIPAL SALT-PRODUCING COUNTRIES.



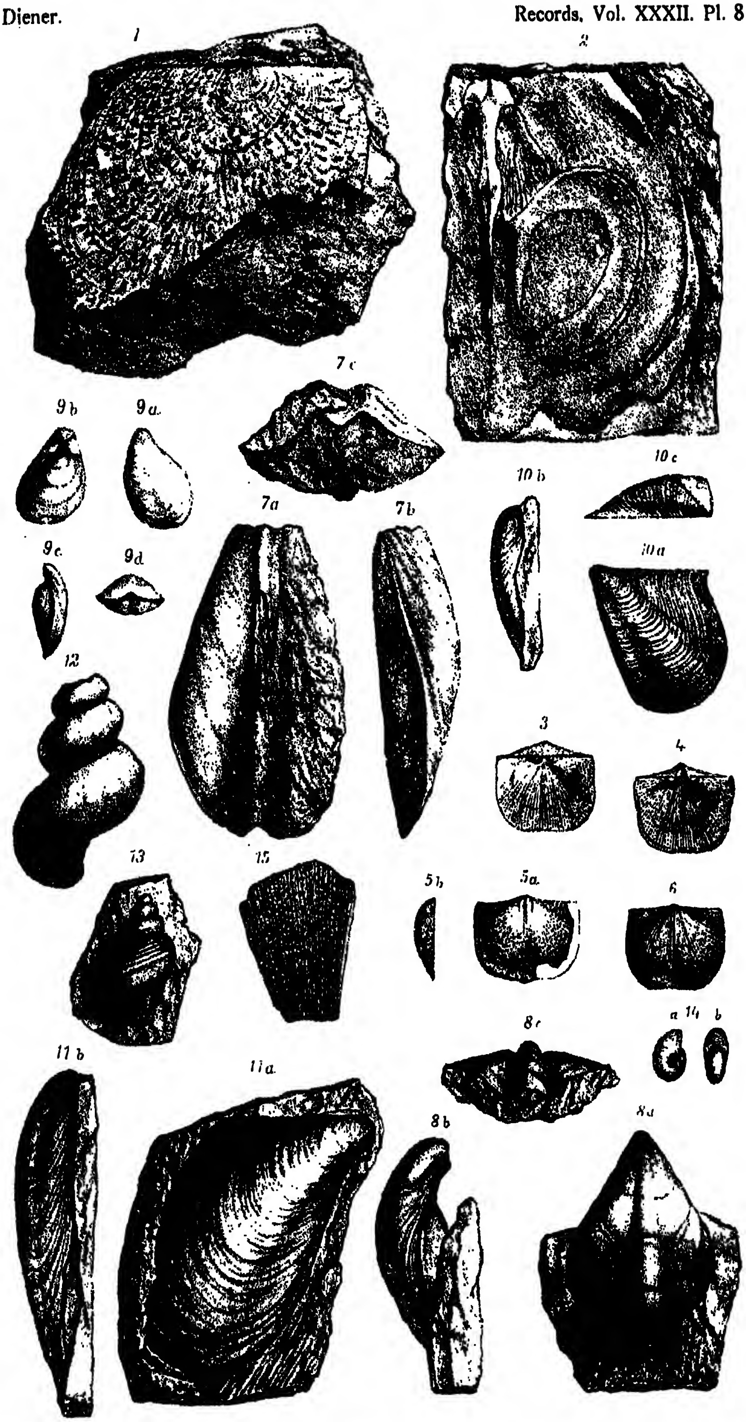
PRODUCTION OF UPPER BURMAH OILFIELDS.



OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

C. Diener.

Records, Vol. XXXII. Pl. 8



A. Swoboda, del.

Alb. Berger print.

ANTHRACOLITHIC FOSSILS FROM THE SUBANSIRI GORGE.

G. E. Pilgrim.

Photographed by G. E. Pilgrim.

Bemrose, Collo., Derby, Eng.

CHANNEL OF THE GODAVARI NEAR NANDUR MADMESHWAR.

Photographed by H. H. Hayden. *Bemrose, Collo., Derby.*

CRANIUM OF ELEPHAS ANTIQUUS (NAMADICUS).

Side view taken previous to restoration.

G. E. Pilgrim.

Photographed by E. Vredenburg. *Bemrose, Collo., Dy.*

CRANIUM OF ELEPHAS ANTIQUUS (NAMADICUS).

The scale is indicated by the foot-rule seen between the tusks.

Lith^d and Printed at the Geol. Surv Office, Calcutta.

ELEPHAS ANTIQUUS (NAMADICUS)

G. E. Pilgrim.

Records, Vol. XXXII. Pl. 13

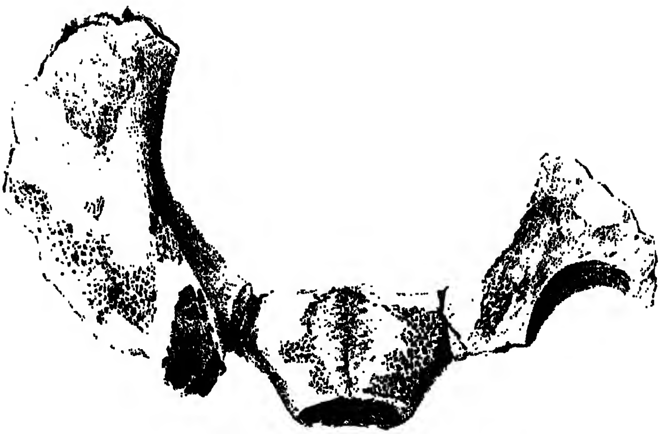


Fig. 1.

Fig. 4.

Fig. 2.

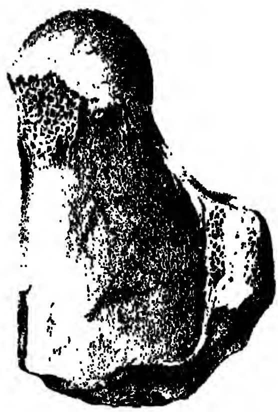


Fig. 3.

Fig. 1. Pelvic Girdle
Fig. 2. Upper portion of Ilium
Fig. 3. Proximal end of Femur
Fig. 4. Distal end of Femur

H. H. Hayden. Photo.

Lith^d and Printed at the Geol. Surv. Office, Calcutta.

ELEPHAS ANTIQUUS (NAMADICUS)